CHAPTER 1
COLUMBIA RIVER CHANNEL NAVIGATION ANALYSIS

1.1. Introduction

The navigation practices of deep-draft vessels on the Columbia River influence the channel design and potential benefits of any channel improvement project. Especially important are the practices of container ships and bulk grain carriers that could take advantage of a deeper channel. The existing navigation practices are the product of the combined effects of river stages, channel depths, size, speed and scheduling of vessels, operating requirements of the pilot groups, and policies of the shippers and government regulators.

To define the navigation practices of container ships and bulk grain carriers on the Columbia River, a detailed study was made of transits that occurred in 1991 through 1993. The goals of the study were to identify the operating limits of ships that might benefit from a deeper Columbia River navigation channel. The study analyzed the number of transits, vessel drafts, departure timing, and underkeel clearances. Additional transit data from 1994 and 1995 was used to supplement the detailed analysis of vessel drafts. The results of the analysis were then presented to shippers and pilots for concurrence and/or refinement.

In the following discussions, the term “draft” will be used to refer to a ship’s draft in the fresh water Columbia River channel. For ships with drafts in the range of 36- to 40-ft, the fresh water draft is about one foot deeper than the salt-water draft.

1.2. Navigation Database

To conduct the study of navigation practices, a large database was compiled for Columbia River transits that occurred from 1991 through 1993. Data collected included vessel characteristics, transit information, water surface elevations, and channel depths.

1.2.1 Vessel Transit Database

The Port of Portland compiled an extensive array of information on nearly 6,000 Columbia River vessel transits that occurred from 1991-1993. The data included vessel characteristics, routes, local port-of-call, arrival and departure times, freshwater sailing drafts, and cargo types and volumes. Data was obtained from the Columbia River Bar Pilots, Columbia River Pilots, Lloyd's Registry, Merchants Exchange, and PIERS.

1.2.2 Controlling Channel Depths

The controlling depths along the channel were determined from Corps of Engineer's 1991-1993 hydrographic surveys. Each navigation bar (approximately a 3-mile reach) was surveyed 6 to 10 times per year during that time period. The individual surveys along the river were examined to identify the maximum channel elevations a ship would experience as it moved through the channel. A high bottom elevation had to occur over 200-300 ft of the 600-ft wide channel before it was considered a controlling depth. Shoals along the edge of the channel were not considered to be controlling factors in navigation because ships have the ability to sail around them.

1.2.3 Water Surface Elevations

Observed water surface elevations were obtained from a series of six gages operated by the National Weather Service for the Port of Portland as part of a river stage forecasting system. These gages provide real time water surface elevations that are used in a river stage prediction computer model and can be used by Pilots to plan vessel departures. The gage locations and datum are:

Location	River Mile	Datum Elevation in Feet	
Astoria	18	0.00 MLLW	-3.07 NGVD
Skamokawa	35	0.00 CRD	-2.15 NGVD
Wauna	42	0.00 CRD	-1.76 NGVD
Longview	67	0.00 CRD	-0.34 NGVD
St. Helens	86	0.00 CRD	0.89 NGVD
Vancouver	106	0.00 CRD	1.82 NGVD

1.3 Navigation Practices Analysis

1.3.1 Vessel Draft Analysis

The first step in the navigation practices analysis was to identify which types of ships might benefit from a deeper navigation channel. The sailing drafts for inbound and outbound transits were reviewed for trends. As Figure 1 shows, outbound drafts are significantly deeper than inbound drafts. The difference between inbound and outbound drafts was expected because export tonnage far exceeds import tonnage on the river. It was determined that the navigation analysis would concentrate on the outbound navigation practices.

The nearly 1000 outbound transits with drafts over 36 ft were then examined to identify the type of cargo and the departure port. This examination identified three groups of ships that might benefit from a deeper channel. The three groups were; the panamax class bulk carriers that loaded corn from the Port of Kalama, bulk carriers that loaded wheat from elevators in Portland and Vancouver, and container ships that called at the Port of Portland. Discussions with shippers and pilots confirmed that those three groups of ships were most likely to benefit from a deeper channel.

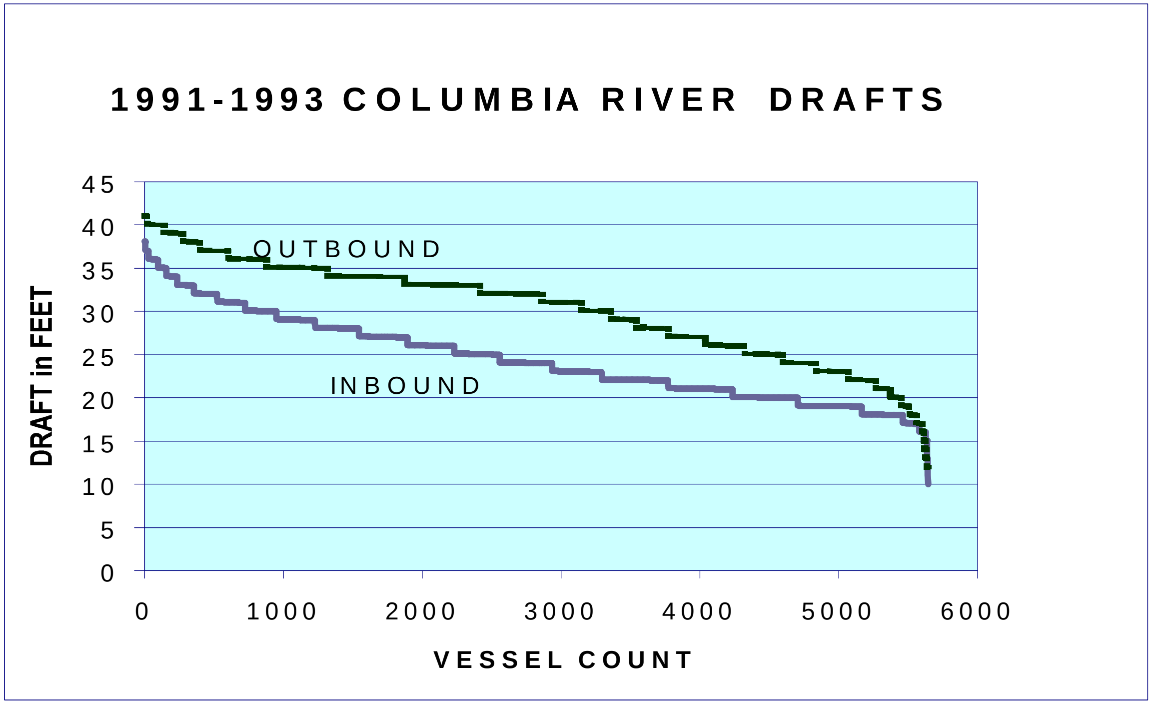

Figure 1. Observed inbound and outbound drafts for all vessel types during 1991-1993. Both data sets have been sorted independently to plot from maximum to minimum.

The panamax class bulk carriers that loaded corn from the Port of Kalama had the deepest drafts. More than 150 of the 487 ships that departed Kalama had design drafts over 40 ft and 107 ships had sailing drafts of 40 ft or more. The deepest draft departing Kalama was 41.6 ft.

There were approximately 1200 bulk carriers that loaded wheat in Portland and Vancouver. Only 25 of those ships had outbound drafts over 39.9 ft, however there were over 460 ships with outbound drafts of 36 ft or more. The deepest outbound draft was 41.3 ft.

The final group was the 650 container ships that called at the Port of Portland. The design drafts for those ships were mostly 38 ft, with some ships having design drafts of 42 ft. Only 62 container ships had outbound drafts over 35.9 ft and only one had a 40-ft draft. Figure 2 shows the design, inbound, and outbound drafts for each container ship transit. The data has been sorted by outbound draft, and shows the corresponding inbound draft and the ship's design draft. As Figure __ shows, a few container ships enter the river with drafts over 35 ft.

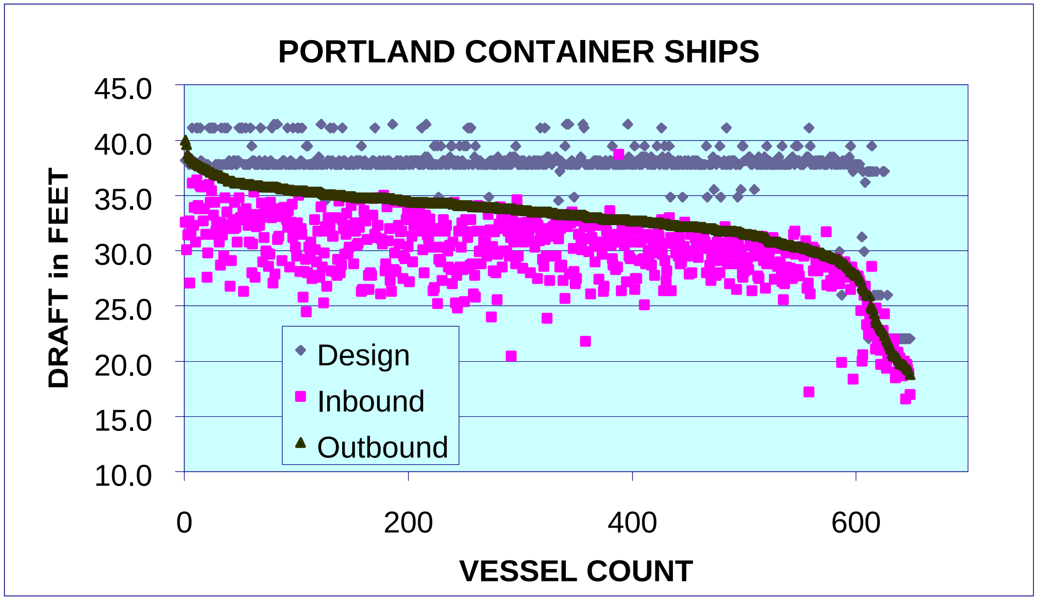

Figure 2. Design, inbound and outbound drafts of container ships transiting the Columbia River in 1991-1993. The data has been sorted to present the outbound drafts in descending order, with the related design and inbound drafts plotted at the same x-axis location.

1.3.2 Transit Modeling

To fully define navigation practices, it was necessary to determine the minimum depth of water and minimum underkeel clearance acceptable to the three groups of ships identified above. To evaluate those parameters, a computer model was developed to reproduce actual transits. The model used actual ship draft and sailing time, channel controlling depths, and observed river stage data to calculate vessel speed and squat, depths of water available and underkeel clearance. A total of 309 transits were reproduced, including 120 bulk carriers from Kalama and 112 bulk carriers from Portland/Vancouver, all the bulk carriers had outbound drafts of 38 ft or more. Ships over 38 ft draft were used because it incorporated most of the panamax class ships and those ships that were making the most use of the water depth available. For container ships, 67 ships with drafts of 35.5 ft or more were analyzed. These were the deepest draft container ships and all had design drafts over 38 ft.

The model used the sailing time from the port of departure to Astoria to computer the average vessel speed. The average speed was then used to compute the ship’s squat (the sinkage of the stern of a ship as it moves through the water). Since squat is roughly proportional to the ship’s speed squared, the faster container ships experience more squat than the slower bulk carriers.

River stages were interpolated from the hourly gage data and the timing of the transit. At the gage sites the stage during the transit was interpolated from the hourly stages bracketing the transit time. The river stages at locations away from the gage sites were interpolated based on timing and distance to the upstream and downstream gages. The stage was calculated at each navigation bar along the transit to produce a continuous water surface profile.

The total water depth available at each bar was calculated by adding the computed river stage, feet above or below CRD, to the controlling depth, in feet below CRD, taken from the channel surveys. The underkeel clearances were then the differences between the total water depth available at each bar, and the sum of the ship’s draft and squat. Figure 3 shows typical results from the transit model. The results for each transit were then sorted to identify the minimum and maximum values for river stage, controlling depth, total water available, and underkeel clearance.

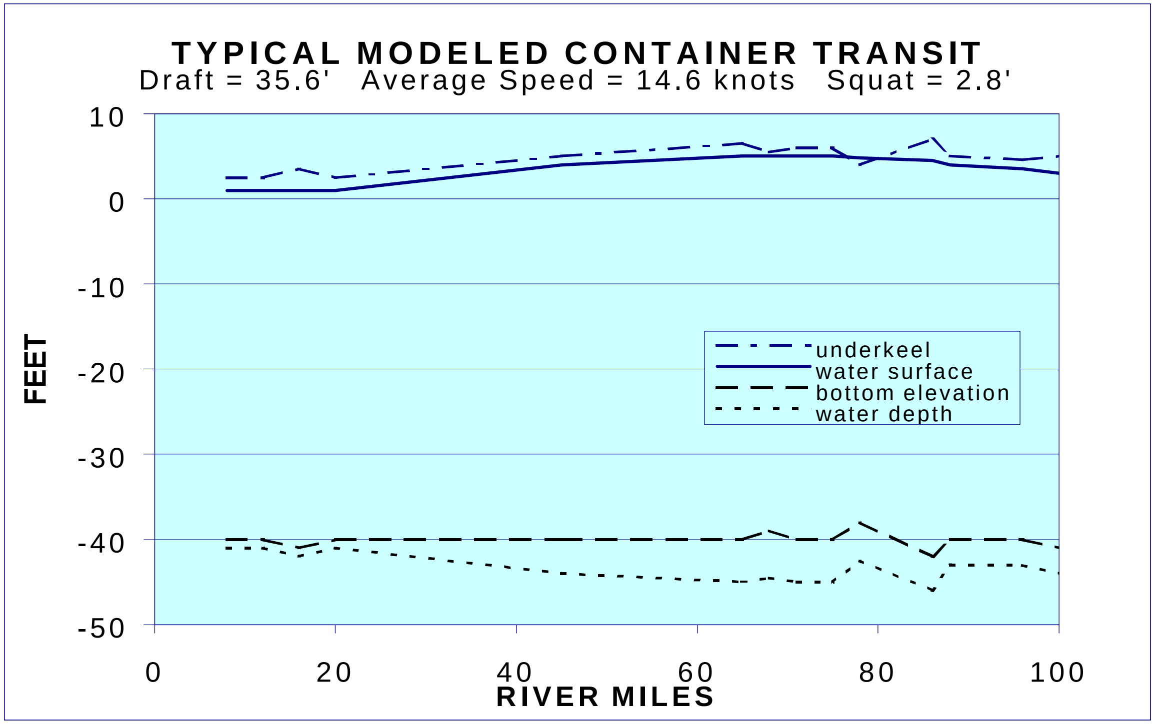

Figure 3. Vessel transit model results showing the reproduced water surface elevation, channel bottom elevation, total depth of water available, and underkeel clearance along the channel.

1.4 Operating Practices

A set of operating practices was defined for each of the three groups of ships likely to benefit from a deeper channel. Target values were identified for draft and minimum underkeel clearance. The target values were defined as the limiting values acceptable under normal operations. The values were initially identified from the transit modeling results and then confirmed during discussions with shippers and pilots.

1.4.1 Kalama Bulk Carriers

The bulk carrier fleet that calls at Kalama primarily loads corn. The fleet is comprised of two classes of ships, handy size vessels with design drafts of 30-36 ft and panamax class vessels with design drafts of 40-44 ft. Because corn can be purchased and shipped in large lots, panamax class ships comprised about 40 percent fleet, as shown in Figure 4.

The bulk carriers that call at Kalama typically remain in the river for a week or more and attempt to load as much grain as possible before departing. The panamax ships will delay their departure to take advantage of the maximum water depth available to load more grain. However, as Figure 4 shows, nearly all of the panamax vessels left Kalama light loaded, while the handy size ships tended to sail at or over their design drafts.

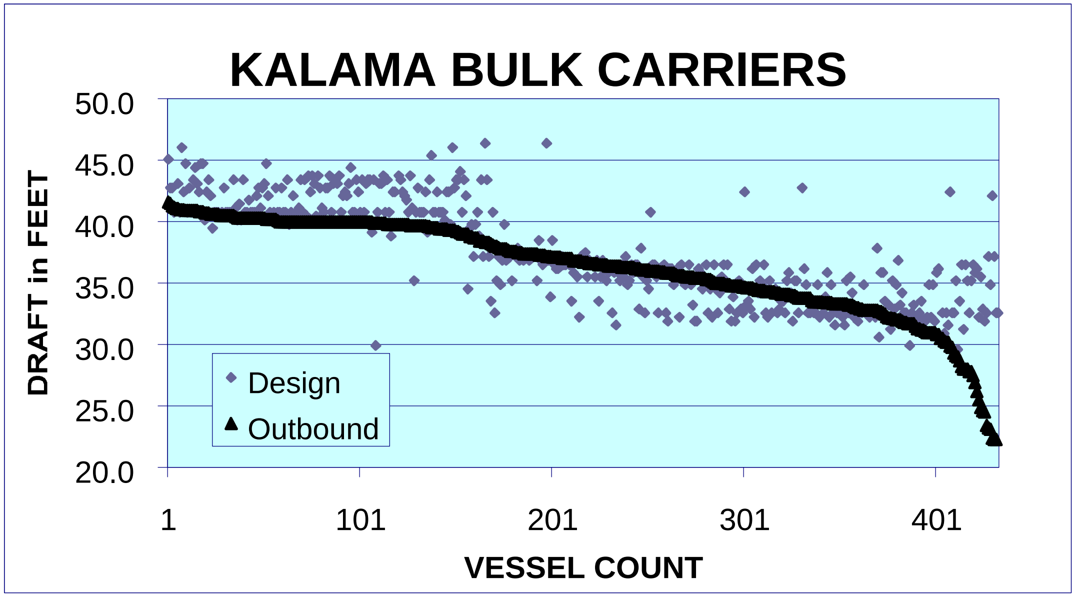

Figure 4. Design and outbound drafts for bulk carriers calling at Kalama in 1991-1993.

Figure 5 shows that from 1991 through 1993, of the 120 ships with sailing drafts of 38 ft or more, 34 sailed with a 40-ft draft and 43 sailed with drafts over 40 ft. Forty-feet was initially selected as the target sailing draft from Kalama because it was the median draft for the panamax ships. Drafts deeper than 40 ft are possible but require better than average channel conditions. The 1994-1995 draft data supported a target draft of 40 ft as there were 46 ships with 40 ft draft and only seven over 40 ft.

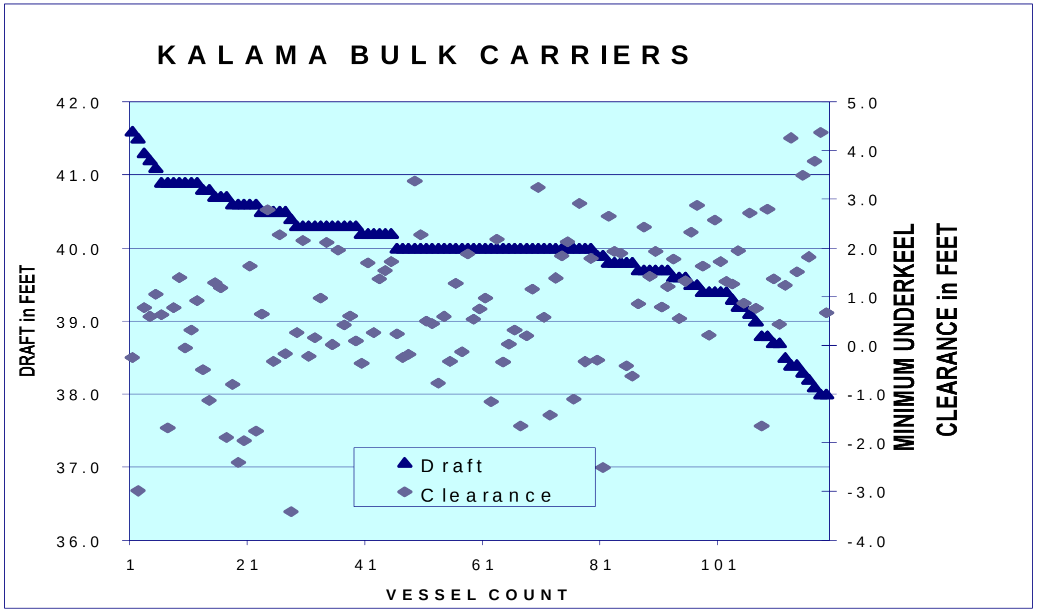

Figure 5. Outbound draft and corresponding minimum underkeel clearance for the 120 ships that departed Kalama with drafts of 38 ft or more, in 1991-1993. The data has been sorted to present outbound drafts in descending order.

As shown in Figure 5, the minimum underkeel clearance was 0.0 ft or less on 33 of the modeled transits. The negative underkeel clearance values probably indicate, a limitation in the modeling method, the ship slowed to reduce squat or maneuvered around the shoal during the transit, or the ship actually touched bottom during the transit. The minimum underkeel clearance typically occurs only at one point along the channel, often just for 100-200 ft as the ship passed across the top of a single sand wave on the bottom of the channel. Because of the frequency of occurrence of 0.0 ft of underkeel clearance, limited potential for cargo damage, and the short duration of the event, 0.0 ft was selected as the target underkeel clearance for the panamax ships sailing from Kalama.

1.4.2 Portland/Vancouver Bulk Carriers

Grains, mainly wheat and barley are the main bulk cargoes exported from Portland and Vancouver. The grain fleet is comprised of both handy size and panamax class bulk carriers, as shown in Figure 6. Wheat constitutes the majority of the grain exports and is mainly shipped in handy size vessels. During 1991-1993, almost as many panamax class grain ships called at Portland/Vancouver as called at Kalama, however because of the size of the fleet, Panamax class ships made up only about 10 percent of the fleet.

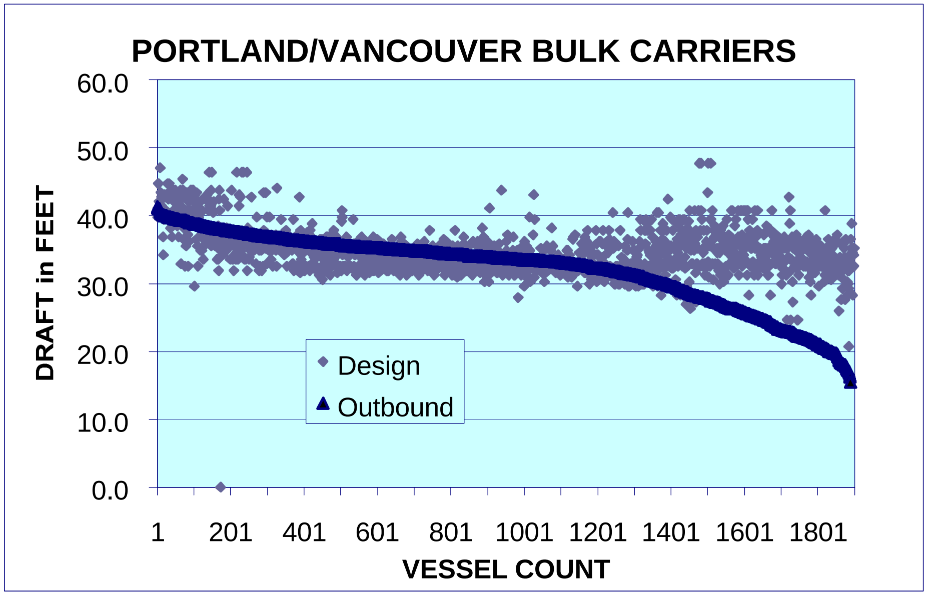

Figure 6. Design and outbound drafts for bulk carriers calling at Portland and Vancouver in 1991-1993.

The bulk carriers that call at Portland and Vancouver typically remain in the river for a week or more and attempt to load as much grain as possible before departing. The handy size ships tended to sail at 33-35 ft drafts, often 2-3 ft over their design drafts. To maximize cargo tonnage, the panamax ships often scheduled their departure to take advantage of the maximum water depth available. However, as Figure 6 shows, nearly all of the panamax vessels sailed light loaded.

A target draft of 39 ft was selected for the Portland/Vancouver panamax size grain ships. Figure 7 shows that in 1991-1993, 39 ft was the median draft of grain ships with drafts over 38 ft. In 1994-1995 there were 139 ships with drafts of 38 ft or more, and the median draft remained 39 ft. This target draft is 1.0 ft less than that identified for Kalama, for the same type of ships. The difference in target drafts is probably due to more limiting channel conditions during the longer transit from Portland/Vancouver. Ships from

Portland/Vancouver pass through two low water surface points in the channel, while ships from Kalama only need to pass through one low water point. The longer transit also increases the likelihood of encountering a shoal.

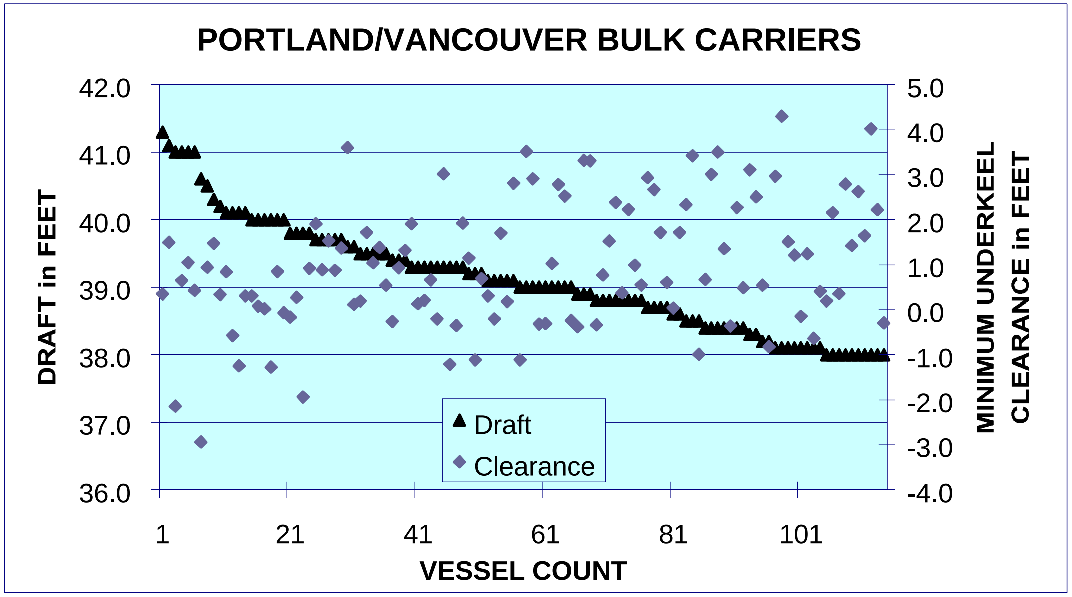

Figure 7. Outbound draft and corresponding minimum underkeel clearance for the 112 ships that departed Portland and Vancouver with drafts of 38 ft or more, in 1991-1993. The data has been sorted to present outbound drafts in descending order.

The minimum underkeel clearance analysis results in Figure 7 show a trend very similar to that of the Kalama analysis, with 24 model runs resulting in zero or negative values. For the reasons given in the above Kalama discussion, 0.0 ft was also selected as the target minimum underkeel clearance for Portland/Vancouver bulk carriers.

1.4.3 Portland Container Ships

Container ships operate much differently than the bulk carriers. They are schedule driven and only make short, 1-2 day, calls in the Columbia River as part of an Asia-North America route. Container ships must be able to arrive and depart on set schedules, without delaying for low river stages. Portland is the last North American port-of-call for many container ships. Those ships could be expected to load as much cargo as possible and sail at or near their design drafts. However, the container ships are also concerned about underkeel clearance, because they carry cargo that is fragile and of high value.

As shown on Figure 2, the vast majority of container ships have design drafts around 38 ft, with a few larger 41-42 ft draft ships. The departure drafts show a clear break in slope at 36 ft. This break does not correspond to a change in ship size as it did for the bulk carriers and was interpreted as a change in operating practices by the container ships. The 36-ft draft was therefore selected as the target draft for container ships. In discussions with shippers it was confirmed that 36 ft was their target draft because they could depart at any time without being delayed by a low river stage.

Because of the schedule that container ships are on, few of them try to make full use of the available water depth. In general, the container lines plan to have available on the dock the maximum amount of cargo that can be loaded onto the vessel within the scheduled loading time. However, they do not normally load more than the target draft, even if there are time and cargo available. Only 35 of 649 container ships had departure drafts over 36 ft during the 1991-1993 period. The container traffic increased significantly in 1994-1995 and 157 ships, out of 560, had drafts over 36 ft. In 1994-1995 one container line operated a group of panamax size ships that regularly sailed with drafts in the 38-40 ft range. The container line consulted with the Columbia River Pilots to schedule departure times, sometimes delaying a ship’s departure, to take advantage of the maximum water depths available.

As Figure 8 shows, of the 67 container ship transits modeled, only 5 had calculated minimum underkeel clearances of less than zero. There were 17 ships with minimum underkeel clearances of less than 2.0 ft. Two feet was chosen as the target minimum underkeel clearance since that value was exceeded by 75 percent of the 67 deepest container ships. This value fit well with the general container ship guideline of a 4-5 ft allowance for squat and underkeel clearance.

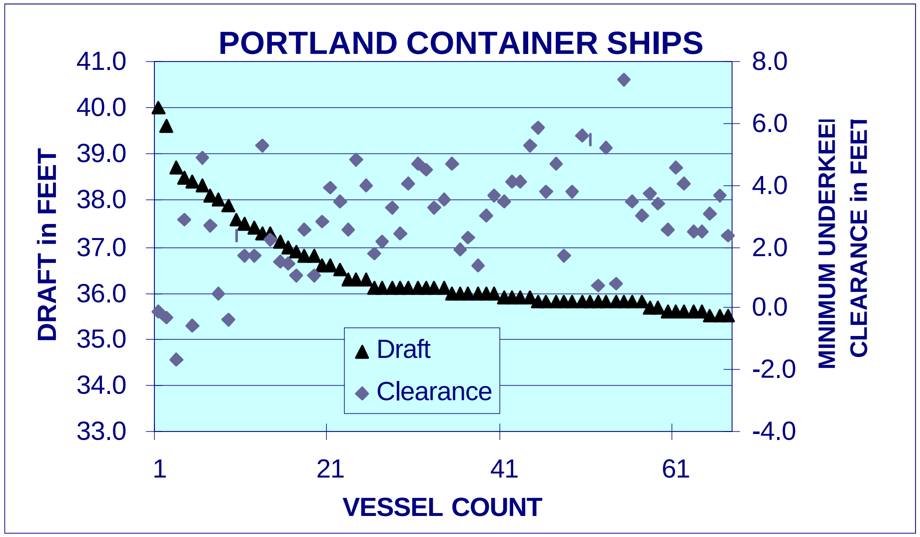

Figure 8. Outbound draft and corresponding minimum underkeel clearance for the 67 container ships that departed Portland with drafts of 35.5 ft or more, in 1991-1993. The data has been sorted to present outbound drafts in descending order.

CHAPTER 2
MOUTH OF THE COLUMBIA RIVER NAVIGATION ANALYSIS

2.1 Introduction

This analysis of navigation at the mouth of the Columbia River (MCR) was made to determine the compatibility of the existing 55-ft entrance channel with the proposed 43-ft river channel. Specific issues are whether MCR would have to be deepened to handle the 43-ft draft ships expected in the proposed river channel and to estimate potential delays those ships might experience, at MCR.

2.2 Background

The navigation channel at the mouth of the Columbia River (MCR) is a tiered channel, with the north side being 55 ft deep by 2000 ft wide and the south side being 48 ft deep and 640 ft wide. The55 ft depth was intended to optimize the operations of the 40-ft Columbia River navigation channel. Improvement of the MCR is not part of the current channel deepening study. Therefore, it is necessary to determine if deeper draft ships might experience delays due to depth limitations at the MCR.

The Interim Feasibility Study and Final Environmental Impact Statement for the 55 ft MCR channel were-completed in March 1983. The project design was based on the results of the "Columbia River Entrance Channel Deep-Draft Vessel Motion Study" (VMS) completed by Tetra Tech, in September 1980. The VMS measured heave, roll, and pitch, to determine the vertical excursions of 53 ships, over a two-year period. A correlation was developed between wave height and vessel excursion that accounted for varying wave and vessel characteristics.

2.3 MCR Design

The MCR design criteria was for a 36-ft fresh-water (FW) draft vessel to be able to transit MCR 95o/0 of the time during "safe" wave conditions without exceeding the design excursion. Safe wave conditions were defined as waves less than 10 ft high, a condition that occurred 95% of the time according to the wave forecast used in the design. The design excursion was then defined as the value for which 95% of the excursions during 95% of the transits would not be exceeded. The resulting design conditions were as follows:

FW Draft (ft)	Design Excursion (ft)	MCR Depth (ft)	Min. Tide Stage (ft)	Max. Wave Height (ft)
36	16.5	55	0	8 (est.)
40	16.8	55	4	8 (est.)

As a comparison, on 7 of the 53 VMS transits the wave heights exceeded 10 ft and maximum downward excursion exceeded 20 ft on 6 VMS transits.

Given the above MCR conditions, a 55-ft deep MCR would be open to 36-ft FW draft ships 89% of the time and to 40-ft FW draft ships 44% of the time, based on combining the wave height and tide stage frequency curves used in the design report. Stated another way, the bar could be expected to be closed for 960 and 4900 hours each year for 36- and 40-ft drafts respectively.

2.4 Bar Pilots Operating Practices

As standard operating practices, the Columbia River Bar Pilots have two factors related to physical conditions in the river and entrance that limit transits on the MCR, The primary limitation is the underkeel clearance in the river channel between RM's 6 and 13. This restricts the draft and departure time of some deep-draft ships. The second limitation is the wave conditions at MCR, which can close the bar and prevent a ship from departing.

2.4.1 Underkeel Clearance Requirements

The minimum underkeel clearance in the river channel downstream of Astoria is normally the controlling factor for draft and time of departure. The standard operating practices for minimum underkeel clearance are; 4 ft on a falling tide, and 3 ft on a rising tide at Astoria. These are safety clearances and do not include allowances for squat. Squat is kept to a minimum by sailing at low speeds. The safety clearances are the same for both bulk and container ships. These, underkeel clearances do not correspond to a specific draft limitation because they are a combination of ship draft, controlling channel depth, and tide stage. Ships with 36-ft or less FW draft can meet the underkeel requirements essentially anytime, but about half the 40-ft FW draft ships must delay their upriver departures to wait for suitable tide stages.

The deeper draft ships time their departures from the upstream ports so their arrival at Astoria coincides with the required tide conditions. If a ship delays to wait for the tide, the ship must delay its departure from the upstream port, as there is no place to stop and anchor in the estuary. Only in an extreme case, such as a sudden storm, would a loaded ship be stopped and anchored in the estuary after departing an upstream berth.

2.4.2 Bar Closures

The standard practice for determining bar closures is for the individual pilot to decide if the wave conditions are unsafe either for the pilot boat or the ship scheduled to transit MCR. The bar is generally closed when there are breaking waves in the entrance. However, for less severe wave conditions the pilot must decide on the safety of a transit based on the characteristics of the ship and the waves. The bar pilots do not differentiate based solely on a ship's draft when deciding on the safety of an MCR transit. A ship's ride and steerage characteristics are also important factors in deciding the risk of a transit. The draft, length, beam, type and location of cargo, and hull design can all influence the ride and steerage of a ship.

Pilot experience has shown that ship length is an important factor in determining ship handling across MCR. Ships of around 600 ft in length experience large amounts of plunge because of the way they interact with the short wave lengths present at MCR. The longer, deeper-draft Panamax ships have significantly less plunge because their length dampens the wave effects. The reduced plunge offsets the deeper draft and results in less total penetration for the longer ships. However, rolling becomes more of a concern with the larger ships.

2.5 Regulatory Environment

The maximum draft on the Columbia River may be more a function of government regulation than physical parameters. The regulatory environment at the Oregon Board of Maritime Pilots tends to hold pilots at fault for any incident with a ship drawing over 40 ft, regardless of the circumstances. Given the potential risk of losing their license, bar and river pilots are hesitant to pilot ships over 40 ft draft available to do in the existing channel even if there were sufficient water depths so.

2.6 Observed MCR Operations

The available data on MCR transits was reviewed to determine historical practices. The total length of bar closures and transit drafts were reviewed for the time period 1961 to 1995. Also departure stage and tide condition data from 1991 through 1993 were examined. Data provided by the Bar Pilots showed the total length of time that MCR was closed each year declined steadily between 1961 and 1987, Figure 1. While over the same time period, the deepest drafts transiting MCR increased from 33-ft to 40-ft (FW draft).

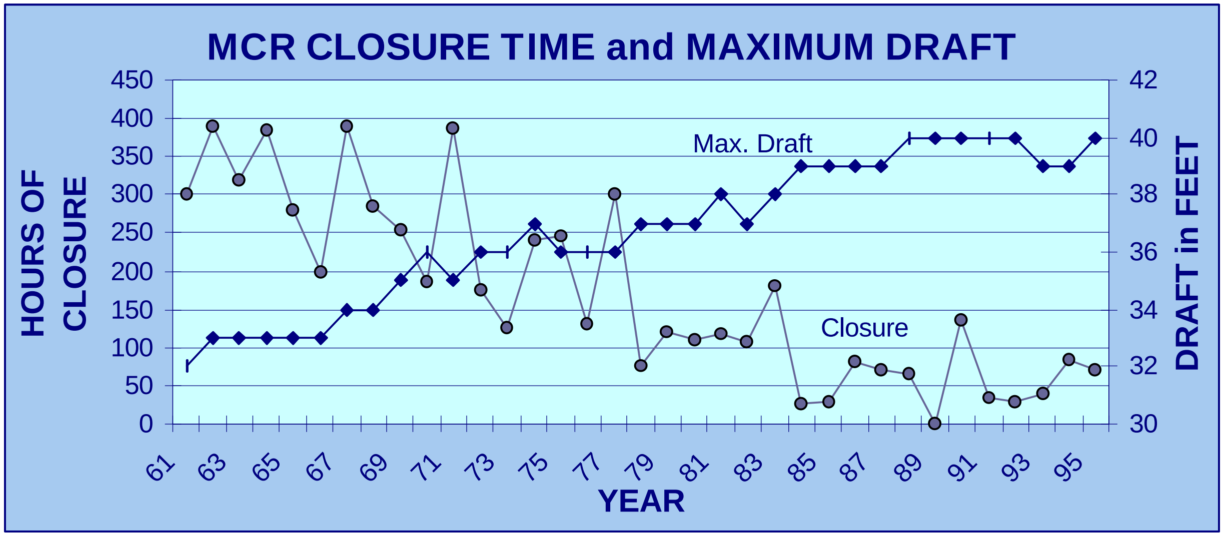

Figure 1. Hours of bar closure and maximum draft of ships transiting MCR each year since 1961.

In 1964, with a 35-ft river channel and 48-ft entrance, the 4-year average for bar closures was 350 hours per year and the deepest drafts were around 33 ft. In 1971, with a new 40-ft river channel and a 48-ft entrance, the bar was closed an average of 275 hours per year and drafts had increased to around 36 ft. By 1981, just prior to deepening the entrance, the bar closures had decreased to a 4-year average of only 105 hours per year and drafts increased to 38-ft. After deepening the entrance to 55-ft, bar closures fell to an average of near 50 hours per year and the deepest drafts increased to 40 ft.

There are clear trends of declining closure time and increasing drafts. However, the two trends may not be directly related to the depth of the MCR channel. New pilot boats received in 1967 and 1977 improved the pilot's ability to cross the bar in bad weather and contributed to a 70% decline in annual closure time between 1961 and 1981. This decline in closure time occurred without deepening the entrance channel and despite increasing ship drafts. Since 1984, the deeper MCR channel and longer ships were factors in reducing average annual closure time to only 50 hours.

The increases in draft seen at MCR resulted from numerous factors occurring both locally and globally. The global trend to deeper draft ships has been underway for many years and was facilitated locally by deepening the river channel in 1972 and the entrance in 1984. The establishment of the Peavy corn terminal in 1983 brought a fleet of larger ships that caused an increase in the number of ships drawing 40-ft or more. In recent years the increasing size of container ships has also contributed to the increase in 39- to 40-ft draft ships.

The development of the Loadmax stage forecasting system for the Columbia River in the mid-1980's allowed pilots to increase drafts by making better use of the available water depths in the river. It has also helped river pilots plan transits so they can meet the bar pilot's underkeel requirements. Of the 300 deepest draft ships that transited the Columbia River during 1991 through 1993, only about 10% did not meet the bar pilots' underkeel clearance guidelines.

Breaking waves, a hazard to both the pilot boats and commercial ships, are the most common reason for closing the bar. Breaking wave conditions are most severe during the few hours of strong ebb currents within a tidal cycle. However, during the last 10 years the average length of closure has been about 13 hours (1/2 a tide cycle) and the longest ranged from 20 to 36 hours. This suggests that closures are caused by a few large storms that generate high waves for extended periods of time.

2.7 Comparison of Actual vs. Design

There are several puzzling inconsistencies apparent when the 1983 MCR design parameters are compared to actual occurrences. These include the "safe" wave height and total length of closure, the assumed relationship between vessel draft and bar closure, and the expected excursion.

2.7.1 Wave Closures

The first inconsistency is under what wave heights ships will transit MCR. The design report assumed 10 ft as the maximum "safe" wave height that ships would transit, The design data indicated this would be exceeded 50/6 of the time or nearly 440 hours per year. Even during the 10 years before the MCR deepening the bar was generally closed only 100 to 150 hours per year, with a maximum of 300 hours in 1977. Since the MCR deepening, closures have been between 25 and 140 hours per year, far less than might be expected given the "safe" wave height criteria. It seems obvious that ships can and do transit MCR during higher than 10 ft waves. This was even documented in the VMS data that included transits with wave heights of up to 20 ft.

Another comparison of closure conditions was made by selecting two specific years, 1984 and 1992, to see how wave heights and closure times compared to the design assumption. Data from the Bar Pilots indicate that MCR was closed for 25 and 30 hours in 1984 and 1992 respectively, while wave heights exceeded 10 ft for 20% (1750 hours) and 10% (875 hours) of those years, respectively. The wave height/frequency data from 1984 and 1992 suggests that MCR is only closed when wave heights exceed 18-19 ft, which is more consistent with the VMS wave data and the recent annual closure durations.

2.7.2 Draft vs. Closure

The second inconsistency has to do with the bar being closed to some ships but not to others, The 1983 MCR design report predicted that for a given wave height, downward penetration would increase with increasing draft. Therefore, under certain wave conditions, ships with 36-ft draft could cross the bar when 40-ft draft ships would have to wait for higher tide stages to cross. However, experience has shown that the bar is open or closed on a ship by ship bases, with draft being only one of several determining factors.

While the deeper draft ships do frequently transit MCR during high tide, it is because of the underkeel clearance requirements within the river channel and not because of MCR wave conditions. The Bar Pilots' experience with deeper draft ships crossing MCR has shown that they handle better and have less excursion than the shallower draft ships. This runs counter to the findings of the VMS that showed slightly more excursion for the deeper ships. The variance is probably due to the similarity in length of the deeper and shallower draft ships in the VMS, and the greater length of the 40-ft draft ships currently calling on the river.

2.7.3 Excursion

The third inconsistency has to do with how much excursion a ship might experience. A wave height of about 8 ft with an excursion of 16.5 ft was used as the design values for the 55 ft entrance depth. During the VMS, measured excursions exceeded the design excursion by over 4 ft for similar wave conditions. There were also transits that occurred under much higher wave conditions that had excursions up to 9 ft deeper than the design value.

Since both excursion and wave height could exceed the design values, the risk of ships hitting bottom at MCR appears to be much higher than anticipated. Despite the apparent higher risk, there have been no reports of problems with ships hitting bottom at MCR. This suggests that there is less excursion, deeper water, or both at MCR than expected during the design.

The smaller than expected excursion experienced by the long, 40-ft draft ships could account for some of the lack of grounding, but does not explain why shallower ships are not hitting bottom. Changes in hull design and wider beams may have resulted in a reduction in the excursion for some of the shallower draft ships. There is also some speculation that ships may not ground because they are hydraulically cushioned as they near the bottom.

The hydrographic surveys consistently show bottom elevations deeper than 55-ft over most of the entrance channel. Pilots can follow the deep-water channel and gain extra underkeel clearance. The channel reach most exposed to high waves is from RM -2 to RM 0. This reach typically has controlling depths of 58-60 ft, providing an extra 3 to 5 ft of clearance. Ships may also be penetrating a portion of the 2-ft underkeel clearance safety zone. Based on the design assumptions, an extra 3 ft of depth plus 2 ft of underkeel clearance would allow ships to transit under wave conditions just 3 ft higher than the design values.

It appears that for MCR to be open an average of over 99% of the time, downward excursions must be less than originally estimated. This conclusion applies to ships with 34-ft drafts as well as those with 40-ft drafts. This is a critical safety issue that needs to be more clearly defined.

2.8 With Project Operating Practices

The Bar Pilots expect the with project operating practices to be very similar to the current practices. Since the underkeel clearance in the channel is normally the limiting factor, the 43-ft channel should allow 43 ft draft ships to transit the Astoria reach during higher tide stages. The Bar Pilots are confident that MCR can handle 43 ft draft ships without significant delays. There is a likelihood that the Pilots will initially be cautious with the deeper drafts, resulting in some small increase in delays over those currently experienced by 40 ft draft ships, but this is not expected to last long or to be significant.

Based on the excursion analysis done for the MCR deepening, 40 ft FW draft ships should be delayed because of wave conditions nearly 10% of the time. However, the historic record does not support this level of closure. Until the discrepancy between the theoretical results of the design report and actual operations can be explained, the actual operations must be used as the guide on the level of closures that can be expected,

It can only be assumed that the regulatory environment will not change with the deeper channel and that 43-ft draft will be the unofficial maximum in the Columbia River.

2.8.1 Delays

Given the conflicting information on excursions and bar closures, there is much uncertainty in future MCR operations with a 43-ft river channel. Bar closures appear to be determined by the presence of breaking waves that make the bar unsafe for the pilot boats and commercial ships. MCR closures have been insignificant during the last 10 years, averaging only about 50 hours per year. Since this trend is not directly related to ship drafts, it can be expected to continue after the completion of the 43-ft river channel.

The Bar Pilots are expected to continue their requirement for minimum underkeel clearance downstream of Astoria of 4 ft on a falling tide or 3 ft on a rising tide. This will result in delays for 41- to 43-ft FW draft ships similar to those now experienced by 38- to 40-ft FW draft ships. Those delays are listed on the following table.

Draft	Available Transit Time per Tide Cycle	Delay Time per Tide Cycle	Avg. Time per Delay	Probability of Delay	Avg. Delay per Ship
43 ft	13.6 hrs	11.2 hrs	2.8 hrs	45%	1.3 hrs
42 ft	16.4 hrs	8.4 hrs	2.1 hrs	34%	0.7 hrs
41 ft	20.0 hrs	4.8 hrs	1.2 hrs	19%	0.2 hrs

2.8.2 Recommended Analysis

Since the MCR is expected to continue to be closed on a ship by ship, there is a need to refine the wave height, expected excursion and the level of risk of hitting bottom for wave conditions just below the breaking wave level. Given the potential consequences of hitting bottom, it seems like the design should be based on E95 or higher, of the extreme excursion values. The 1983 design failure rate of 5% leaves the potential for some ships to hit bottom up to 10 times during a single transit. The expected and actual excursions both need to be reviewed before the channel design is finalized.

CHAPTER 3
DEPARTURE DELAY ANALYSIS

3.1 Introduction

River pilots of ships with drafts in the 38- to 40-ft range must schedule their departures to meet underkeel clearance requirements within the Columbia River channel and at the mouth. This can require ships to delay their departure from upriver ports for several hours after they have finished loading to wait for favorable tide conditions. The length of a delay depends on the ship's draft, river discharge, tide stages, and controlling depths in the channel.

3.2 Operating Practices

Ship transits on the Columbia River are governed by a numbeer of standard operating practices that are influences by the pilots, vessel type, tide stages, wave conditions, controlling depths, and government regulators. While there have been exceptions to any and all of the following practices, the standard operating practices for the Columbia River are described below.

The designated 40-ft depth of the navigation channel is based on a low-low-water, water surface profile referred to as the Columbia River Datum (CRD). The actual depth of water available in the channel during any given transit depends on the combination of tide, river discharge and controlling depths. Each of those parameters is constantly changing, with tide stage being the critical factor on a day-to-day basis. By taking advantage of tide stages that are frequently 1- to 2-ft or more above 0 CRD and controlling depths greater than 40 ft, a ship may be able to transit with a minimum water depth of 42 to 45 ft.

Underkeel clearance is the critical factor for determining the departure draft of a ship transiting the river channel. Underkeel clearance changes constantly as a ship moves through the river because of the changing river stages and sand waves on the bottom of the channel. Minimum underkeel clearance generally occurs within a short reach of channel near the point of minimum river stage. Because of the limited duration of the condition, minimum underkeel clearances are quite small in the Columbia River. As explained in Chapter 1 of this Appendix, bulk carriers drawing 40 ft are willing to transit with a minimum underkeel clearance of 0 ft, while container ships prefer a minimum of 2 ft.

Tide and wave conditions at MCR also influence operating practices. The Bar Pilots standard practice is for a ship to have a minimum of 3 ft of underkeel clearance on a rising tide or 4 ft on a falling tide. This means that the river pilots of 39-40 ft draft ships must schedule their arrival in Astoria to fall within one of the two daily tide windows for MCR departure, as well as meet underkeel requirements in the river channel. High waves are not usually a factor in departure scheduling. However, waves in the range of 18-20 ft or higher, will close MCR to all ships.

The above minimum values for underkeel clearance and water depth available in the Columbia River would occasionally allow maximum drafts of 43 ft for bulk carriers and 42 ft for container ships. However, regulatory pressure from the Oregon Board of Maritime Pilots limits the maximum draft in the river to 40 ft.

These standard operating practices provide the basis for the delay times presented in the following sections. The expected delay for any given ship could be minimized by agreement between the shipper, and river and bar pilots to work outside of the standard practices.

3.3 MCR Delays

The Bar Pilots guideline is for a ship to have 3 ft of underkeel clearance on a rising tide or 4 ft on a falling tide. This means that 39-40 ft draft ships have two tide windows through which to depart MCR. How closely this is followed depends on the individual pilot and the channel conditions at the time of departure. However, because it is the most likely operating practice, that guideline was used to determine the potential delay times that could be attributed to MCR.

The following steps were followed to calculated delay times.

1. The controlling depth was assumed to be 40 ft CRD for the existing channel and 43-ft for the new channel.
2. The required tide stage was determined for the selected drafts.
3. The percent of the time that river stages would be below the required stage was determined from a stage duration curve for 1991-1993.
4. The total time during a tide cycle when stages were below the required level were divided into two equal periods.
5. Delays could range from 0 to 100 percent of a delay period, and would average 50 percent.
6. Since ships could be ready to depart from port at any time, the probability of a delay would equal the percent of time the tide stages were below the required level.

7. The average delay per Columbia River transit would then be equal to the average delay time multiplied by the probability of being delayed.

Draft in 40-ft Chan.	Draft in 43-ft Chan.	Available Transit Time per Tide Cycle	Delay Time per Tide Cycle	Avg. Time per Delay	Probability of Delay	Avg. Delay per Ship
40 ft	43 ft	13.6 hrs	11.2 hrs	2.8 hrs	45%	1.3 hrs
39 ft	42 ft	16.4 hrs	8.4 hrs	2.1 hrs	34%	0.7 hrs
38 ft	41 ft	20.0 hrs	4.8 hrs	1.2 hrs	19%	0.2 hrs

3.4 River Delays

In order to meet the Bar Pilots requirements at MCR, ships must pass through a low tide somewhere within the river channel. The river pilot can adjust departure time to sail through that low tide at a location with sufficient controlling depth to maintain an acceptable amount of underkeel clearance and still meet the bar pilot's requirements.

The following delays are based on work done by Ogden Beeman and Associates in 1994 for the Port of Portland. Departure drafts have been adjusted from the Beeman work to account for the different minimum underkeel clearance requirements of bulk carriers and container ships.

Container Ships

Draft in		Probability of Delay by Time Increment				Average
		Time Increment of Delay				Delay
40-ft Chan.	43-ft Chan.	0 hrs.	0-6 hrs.	6-12 hrs.	12-24 hrs.	Per Transit
40 ft	43 ft	44%	25%	14%	17%	5.1 hrs.
39 ft	42 ft	73%	21%	6%	0%	1.2 hrs.
38 ft	41 ft	100%				0 hrs.

Bulk Carriers

Draft in		Probability of Delay by Time Increment				Average
		Time Increment of Delay				Delay
40-ft Chan.	43-ft Chan.	0 hrs.	0-6 hrs.	6-12 hrs.	12-24 hrs.	Per Transit
41 ft	44 ft	44%	25%	14%	17%	5.1 hrs.
40 ft	43 ft	73%	21%	6%	0%	1.2 hrs.
39 ft	42 ft	100%				0 hrs.

The delays for MCR and the river are not additive because the river delays are scheduled to meet the MCR sailing windows. The delay that a ship would experience would be the longer of the MCR or river delays.

CHAPTER 4
COLUMBIA RIVER
STAGE FORECASTING SYSTEM ANALYSIS

4.1 Introduction

The demands of world trade place constant pressure on shippers and pilots to transit the Columbia River at deeper drafts. As a result, the Corps of Engineers and the seven Lower Columbia River ports are currently conducting the Columbia River Channel Deepening Feasibility Study to evaluate potential navigation channel improvements. An early finding of that study has been that many of the deepest draft outbound ships are not now taking full advantage of the water depths available in the existing 40-ft navigation channel.

Improvements to the existing river stage forecasting system, commonly referred to as "Loadmax", could allow ships to increase their drafts by providing better forecasts of the water depths available. An improved forecasting system could be implemented and operating in a short period of time. This report summarizes the existing navigation practices and forecasting system, the improvements that could be made to the forecasting system, and the potential benefits to shippers.

4.2 Background

The Columbia River navigation channel is currently authorized and maintained at the depth of -40 ft Columbia River Datum (CRD), from the mouth upstream to River Mile (RM) 105.5 (Figure 1).
However, because the CRD is a low-low-water datum, ocean tides produce river stages that are above 0 ft CRD over 90 percent of the time (Figure 2). Figure 3, shows how the channel depth and stage combine to provide the water depth available for a transit.

For many years, the Columbia River pilots have taken advantage of high river stages to move deep-draft ships through the river. Prior to 1984, they relied on their own experience with the river to guide them in selecting safe drafts. In 1984, the Port of Portland, Portland District Corps of Engineers, National Weather Service, and National Ocean Service determined a need to develop an hourly river stage forecast and a real-time river stage monitoring network for the Columbia River deep-draft navigation channel. The Northwest River Forecast Center (NWRFC) created an interactive dynamic wave computer model, capable of providing a three day, hourly stage forecast for the six sites along the channel shown on Figure 1. The three day forecast allowed pilots and shippers to plan departure times to make better use of higher river stages to increase safe vessel drafts on the river. In 1988, NWRFC extended the forecast period to six days.

4.3 Forecasting System Limitations

The analysis of standard operating practices (Chapter 1 of this Appendix) found that while maximum drafts had increased to over 41-ft for bulk carriers and to 40-ft for container ships, the water depths available were not consistently being fully utilized. Ships are routinely limited to the predetermined target drafts listed in Chapter 1. However, Figures 4, 5, and 6 show that both bulk carriers and container ships sailing at their respective target drafts commonly had underkeel clearances that ranged from l-ft less to 4-ft greater than the minimum acceptable clearances. Bulk carriers occasionally may touch bottom on shoals with bed elevations above 40 ft CRD project depth. This does not seem to be a serious problem, but is a safety concern. The range of underkeel clearances indicates there are opportunities to increase both draft and safety for the deepest draft transits on the Columbia River.

It appears from Portland District's analysis of Columbia River navigation practices, that the existing river stage forecasting system is not providing an adequate forecast for shippers to make optimum use of water depths available.

A few general comments were made about the reluctance of some shippers to rely on the forecasts, but no specific explanation of its limitations came out during discussions with shippers or pilots. The Corps' own analysis suggests four main limitations in the existing river stage forecasting system:

1. Concern about the accuracy of the river stage forecast.

2. The forecast may not extend far enough into the future to allow container lines to adjust cargo schedules to take advantage of opportunities for greater than minimum available water depths.

3. Navigation channel shoal conditions are not included in the forecast, therefore the comprehensive water depth available is not being provided.

4. The river level forecast is presented in a tabular form that does not give a clear picture of expected river conditions, and may be difficult to understand for someone unfamiliar with the Columbia River.

Container ships that have design drafts of 38- to 41-ft are currently targeting a draft of only 36-ft. The container lines are concerned about the reliability of service, therefore they schedule only enough outbound cargo to be at the docks to load to a predetermined draft. To be useful to the container lines, the river stage forecast must provide reliable data far enough in advance to allow cargo scheduling to maximum drafts.

Bulk carriers use more of the water depth available to them than the container ships, but they still do not make maximum use of the water depths available. Bulk carriers with 40- to 41-ft drafts currently delay their departures for several hours to take advantage of higher river stages. To maximize their drafts and avoid touching bottom, bulk carriers need forecast and observed data available to them right up to their time of departure. The most recent shoaling conditions are also valuable to bulk carriers because of the zero underkeel clearance at which they may transit.

4.4 THE PROPOSED SOLUTION

The existing river stage forecasting system could be greatly improved upon. Providing a more detailed forecast, in a user-friendly format can solve limitations 2, 3, and 4 above, relatively easily. Concerns about the accuracy of the forecast can also be addressed, but will take longer to resolve.

The procedures used by Portland District to analyze deep-draft navigation practices can be adapted to provide forecasts of not only river stages, but also water depth available and estimated underkeel clearance. Updated one- or two-dimensional hydraulic models could be used to improve the accuracy of the river stage forecast. The controlling shoal elevations for each reach of the channel would come from Corps of Engineers' hydrographic surveys and can be updated at approximately three-month intervals. The resulting forecast could then present total water depths available along the channel for a scheduled transit, in a user friendly, graphical format.

The entire forecast could be computerized so those forecasts could be obtained in a few minutes. The Pilots and shippers could enter a desired departure time and sailing draft, and view the forecast river stages, current shoal conditions, and water depth available all along the river for the transit. The point of minimum water depth available could be located and last minute changes made to departure time or vessel speed to optimize draft and safety. The current six-day forecast could be extended if necessary for better container cargo scheduling.

The accuracy and reliability of the forecast could be enhanced through improved hydrodynamic computer modeling and monitoring of forecast results. A monitoring program could compare the actual river stages at the six stage measurement sites to the forecast stages. The results of that monitoring could be provided to the users and also used to improve the hydrodynamic model.

4.5 THE BENEFITS

Implementation of the proposed improved forecasting system would provide shippers better opportunities to take full advantage of the water depths available. The full benefits to shippers are difficult to estimate, but an immediate l-ft increase in the target drafts for containers and bulk carriers seems achievable. Figures 4, 5, and 6 give an indication of the potential draft increases that could have been gained by the ships included in the Corps' navigation practices analysis. Those figures indicate that about half the time, the deepest draft ships in 1991-1993 could have gained from 1- to 3-ft of outbound draft. With a more reliable extended forecast, container lines would frequently be able to fully load their 38-ft draft ships that make up the majority of the existing container fleet.

Increased safety will be an additional benefit of including shoaling conditions in the forecast. The negative underkeel clearances that were found during our analysis often occurred at shoals that had reduced channel depths to 37- to 39-ft CRD. These locations can be seen on the forecast plots and drafts or departure times adjusted to avoid undesirable conditions.

4.6 CONCLUSION

The water depth available in the existing 40-ft navigation channel is not being fully utilized. The proposed improved forecasting system would facilitate increased maximum drafts for container ships and bulk carriers. The improvements could be made in a short period of time, by adapting procedures recently developed by the Corps of Engineers. The resulting forecast could provide not only river stages, but also controlling bed elevations, water depths available and underkeel clearances. The proposed forecast could also increase navigation safety by making it easier to locate points of minimum underkeel clearance.

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CHAPTER 5
EXISTING UTILITY CROSSINGS

1.1 INTRODUCTION.

1.11 General. A study of the existing utilities crossing the Columbia River (RM 0 to RM 105.5) and the Willamette River (RM 0 to RM 11) was undertaken to determine impacts from lowering the Columbia River Channel from the existing 40-foot depth to a 43-foot depth (48-foot depth overexcavation along the lower Columbia River and 45-foot depth overexcavation along the Willamette River).

1.12 Available Information. Available information to determine CRCD impacts to existing utility crossings included review of available regulatory permits; review of cable and pipeline crossings included in the Columbia River Maintenance Disposal Plan, September, 1991; and phone interviews with utility owners.

1.2 COLUMBIA RIVER UTILITY CROSSING'S (RM 0 TO RM 105.5).

1.21 General. Areas between the following river miles will require dredging to reach a channel depth of 43-feet:

(1) RM 6 - 49
(2) RM 50.5 - 52.5
(3) RM 56 - 101
(4) RM 102.5 - 105.5

1.22 Existing Utility Crossings. Existing utility crossings for the Columbia River are included in Table 1. A summary of those utility crossings being impacted by lowering the channel are shown below:

(1) RM 6.5, US Coast Guard, Four conductor telephone cable between Pt Adams (OR) and Chinook Point (WA), Located @ 45 feet below mean low low water (MLLW).

(2) RM 13.7, Pacific Telephone & Telegraph (US West), Cable crossing between Astoria (OR) and Point Ellice (WA), Depth of cable unknown.

(3) RM 14.5, Pacific Telephone & Telegraph (US West), Cable crossing between Astoria (OR) and Knappton (WA), Depth of cable unknown.

(4) RM 105.5, Spokane, Portland & Seattle Railroad (Burlington Northern), Communication cable crossing under railroad bridge between Hayden Island (OR) and Vancouver (WA), Depth of cable @ 40 feet below the low water line.

(5) RM 105.5, Northwest Natural Gas Company, Six-inch diameter pipeline located under railroad bridge between Hayden Island (OR) and Vancouver (WA), Depth of cable @ 44 feet below the low water line.

1.3 WILLAMETTE RIVER UTILITY CROSSING'S (RM 0 TO RM 11).

1.31 General. The area between RM 0 and RM 11.5 (Broadway Bridge) will require dredging to reach a channel depth of 43-feet:

1.32 Existing Utility Crossings. Existing utility crossings for the Willamette River are included in Table 2. A summary of those utility crossings being impacted by lowering the channel are shown below:

(1) RM 3.5, Portland General Electric, Power cable crossing to Rivergate Industrial Park, Depth unknown.

(2) RM 5.8, Pacific Telephone & Telegraph (US West), Communications cable crossing near the St. John's Bridge, Depth @ 43 feet below low water.

(3) RM 5.9, Portland General Electric, Power cable crossing near the St. John's Bridge, Depth unknown.

(4) RM 7, Spokane, Portland & Seattle Railroad (Burlington Northern), Located under railroad bridge, Four armored communication cables from south side of river and three cables from the north side of river, Depth @ 42 feet below low water.

(5) RM 11.25, Pacific NW Bell, Three communication cables, Depth @ 42 feet below low water.

(6) RM 11.25, Pacific Power and Light (PP&L), Cable crossing, Depth @ 37 feet below low water.

(7) RM 11.25, Pacific Power and Light (PP&L), Six 15KV transmission cables and one communication cable, Depth @ 42 feet below low water.

(8) RM 11.6, Portland General Electric, Power cable crossing under the Broadway Bridge, Depth unknown.

(9) RM 11.6, Pacific Telephone & Telegraph (US West), Six communication cables under the Broadway Bridge, Depth @ 43 feet below low water.

(10) RM 11.6, Pacific Power and Light (PP&L), Three 12KV cables under the Broadway Bridge, Depth @ 42 feet below low water.

1.4 SUMMARY. The submarine cables and pipelines were constructed under Department of the Army permits. The owners of the utilities that would be affected by the proposed channel deepening project are obligated to relocate them at their own expense in accordance with the terms of the permits for their construction.

Table 1--Columbia River Utility Crossings				
No.	**Location**	**Utility Name**	**Description**	**Impacts from CRCD**
1	**RM 6.5**	US Coast Guard	Communications cable between Pt Adams (OR) & Chinook Pt (WA) @ 45 ft below MLLW Four - conductor telephone cable	**Possible Impacts** Permit #1507-24-5, 29 Nov 44 POC Seattle, WA (206) 624-2902, ext. 253
2	RM 8	US Coast Guard	Communications cable	No Impacts (no dredging conducted @ RM 8)
3	RM 9	US Dept of Commerce	Cable crossing @ 46 ft below MLLW (power to Desdomona Sands LS) Two conductors in armored submarine cable for 2400 volt circuit & three conductors for 110 volt circuit. Located @ 46 ft below MLLW	**Possible Impacts** CLW 124/24.1
4	**RM 13.7**	Pacific Telephone & Telegraph	Cable crossing between Astoria and point unknown	**Unknown**
5	**RM 14.5**	Pacific Telephone & Telegraph	Cable crossing between Astoria and Knappton (WA) Depth unknow	**Unknown** Permit # 1507-24-13, 22 Sep 50
6	RM 40.5	Pacific Telephone & Telegraph	Cable crossing @ 51 ft below MLLW	No Impacts
7	RM 53.5	PGE	Pipeline @ minimum 55 ft below CRD.	No Impacts

Table 1--Columbia River Utility Crossings				
No.	Location	Utility Name	Description	Impacts from CRCD
8	RM 72.5 to RM 73	Unknown	Cable crossing which fronts Trojan power plant (unknown)	No Impacts (no dredging conducted between RM 72.5 and RM73)
9	RM 76.75	AT&T	Fiber optic crossing @ 62 ft below CRD	No Impacts
10	RM 76.75	NW Pipeline Corp	Pipeline crossing @ 70 ft below CRD	No Impacts
11	RM 100.4	Olympic Pipeline	Pipeline crossing @ 60 ft below CRD	No Impacts
12	RM 100.5	NW Pipeline Corp	Two 16-in natural gas pipelines. Depth of pipes @ 60 - 65 ft below LW. Project located between Sauvie Island and point near Vancouver Lake	No Impacts Permit # 1507-24-10, 28 Nov 55
13	**RM 105.5**	Spokane, Portland & Seattle Railroad	Communication cable crossing under railroad bridge. Depth @ 40 ft below LW.	**Possible Impacts** Permit # 1507-24-6, 23 Jul 45
13	**RM 105.5**	NW Natural Gas	Six-inch diameter pipeline located under bridge between Hayden Island and Washington shore. Depth @ 44 ft below LW.	**Possible Impacts** Permit # 1507-24-9, Jul 54

Table 2--Willamette River Utility Crossings

No.	Location	Utility Name	Description	Impacts from CRCD
1	RM 2.6	NW Natural Gas Co	16-inch diameter pipeline crossing @ 80 ft below normal water surface	No Impacts
2	**RM 3.5**	PGE	Power cable crossing Depth unknown	**Unknown**
3	RM 5.8	City of Portland	36-inch diameter water line @ 60 ft below LW	No Impacts
4	**RM 5.8**	Pacific Telephone & Telegraph	Communications cable crossing Located under St John's Bridge Depth @ to to 43 ft below LW	**Possible Impacts** Permit # 1507-24-29, 30 Nov 59 Permit # 1507-24-10, 21 Dec 48
5	**RM 5.9**	PGE	Power cable crossing Depth unknown	**Unknown**
6	RM 7	City of Portland	30-inch & 20-inch diameter sewer force main @ 50 ft from MLW	No Impacts
7	**RM 7**	Spokane, Portland & Seattle Railroad	Four armored communication cables from south side and three cables from north side. Cables @ 42 ft from MLW. Located under railroad bridge	**Possible Impacts** Permit # 1507-21-5, 31 Dec 70

Table 2--Willamette River Utility Crossings

No.	Location	Utility Name	Description	Impacts from CRCD
8	RM 7	NW Natural Gas Co	Gas pipeline @ 50 ft below LW	No Impacts
9	RM 7.6	Chevron Pipe	8-inch pipeline crossing @ 60 ft below LW	No Impacts Permit # 1522-15-22, 15 Jun 70
10	**RM 11.25**	Pacific NW Bell	Three communication cables @ 42 ft below LW	**Possible Impacts** Permit # 1507-24-37, 27 Aug 68
11	**RM 11.25**	PP&L	Cable crossing @ 37 ft below MLW	**Possible Impacts** Permit # 1507-24-13, 20 Aug 30
12	**RM 11.25**	PP&L	Six - 15 KV transmisssion cables & one communication cable @ 42 ft below LW	**Possible Impacts** Permit # 1507-24-35, 6 May 68
13	**RM 11.6**	PGE	Unknown. Located under Broadway Bridge	**Unknown**
14	**RM 11.6**	Pacific Telephone & Telegraph	Six communication cables. Located under Broadway Bridge @ 43 ft below LW	**Possible Impacts** Permit # 1507-24-16, 6 Oct 53
15	**RM 11.6**	PP&L	Three 12KV cables. Located under Broadway Bridge @ 42 ft below LW	**Possible Impacts** Permit # 1507-24-32, 12 Apr 66

CHAPTER 6
COLUMBIA RIVER CHANNEL DEEPENING STUDY
ENGINEERING APPENDIX
GEOTECHNICAL INFORMATION

1. Introduction.

a. Purpose. An examination of geotechnical conditions and concerns pertinent to the proposed Columbia River Channel deepening was made to assess significant features and rock quantities for adequate evaluation for the upcoming Pre-Construction Engineering and Design (PED) Phase and construction contract plans and specifications. Feasibility phase studies included review of existing data on location, size, and character of rock bodies within the proposed channel limits; on slopes and foundations for bridge piers adjacent to the channel, and coordinating efforts for mitigation of blasting effects on fish during rock removal.

b. Tasks. Geotechnical tasks completed during the Feasibility Phase Study included a search for and a review of past rock excavation information. This, and an analysis and contour update of the last 7 years of fathometer survey results, provided estimates of rock quantities to be excavated for various proposed channel alternatives. An analysis of foundation conditions for bridge piers was conducted to identify potential problems related to excavation. A preliminary cost estimate was developed for explorations and tasks to be accomplished during the PED Phase, and a plan was developed for mitigation of effects on fish during any rock removal requiring blasting.

2. Methodology.

a. Research. Geotechnical references and data pertaining to general conditions and past studies for the lower Columbia River area were reviewed for information relative to the proposed channel deepening. Data included general texts, design memorandums and previous plans and specifications for rock removal contracts. Information for bridge pier analysis was compiled from exploration information collected from State and local agencies in charge of the bridges. Blasting information was obtained from rock removal contracts from New York District, US Army Corps of Engineers for comparable navigation improvements done to Kill Van Kull and Newark Bay Channels.

b. Coordination. Port authorities and consultants, river users, and geotechnical experts were consulted regarding locations of known rock bodies and navigation hazards that could possibly be rock within or adjacent to the river channel. State and local Government and other Corps Districts provided additional information for analysis and cost projection.

c. Hydrographic Survey Analyses. Columbia and Willamette River hydrographic surveys are completed several times a year to meet the needs of river navigation and channel maintenance. These fathometer surveys accurately record simultaneously both water depths and survey instrument locations. This information is converted to elevations that represent the top of undifferentiated soil and rock materials within the channel and adjacent areas on the survey date. Comparisons were made among all of the hydrographic surveys from 1982 to 1997 for each river reach or bar area upstream from Puget Island Bar. A compilation of the data obtained from these comparisons was used to prepare contour maps of various elevations representative of the deepest depths ever recorded within the reach during that time period. The contours were used to help locate possible rock excavation areas. Possible existing rock bodies to be excavated should only be found in these areas where previous fathometer surveys indicate that the top of undifferentiated materials has never been exposed below those elevations.

d. Rock Quantity Estimates. Rock quantities have been computed for each area where rock is known to exist or adjacent to previous excavation contracts. The Slaughters Bar, Lower Vancouver Bar, Vancouver Turning Basin, and Broadway Bridge areas are included in the rock quantities because of the difficulty of excavation, even though the materials to be excavated may not be in-place rock. Morgan Bar is included as it is suspected to contain rock, even though no explorations have been conducted to verify the existence of rock. Rock quantity estimates were prepared by computing the total amount of material that was present contained within and above the contour interval of the suspect area using the software program INROADS, version 7.0, developed by Intergraph. Basic assumptions used in preparing rock quantities are as follows:

(1) Total rock quantities present within and above a specified contour interval are identified within each known or suspect rock area as solid, in-place material.

(2) Quantities of rock material to be excavated at Slaughters Bar, Lower Vancouver Bar and Vancouver Turning Basin, all of which are on the Columbia River, are based on an elevation of –47 feet, plus one foot paid overdepth. For the Broadway Bridge reach quantities for rock material were computed to –46 plus one. For basalt to be blasted and removed in the Columbia River, quantities were computed to an elevation of -49 feet plus one. Willamette River, basalt quantities were computed to an elevation of –46 feet plus one.

(3) Only volumes inside the contour for the required excavation depth were included in the excavation rock quantities. Quantities outside the excavation contour (i.e., the areas considered to be somewhere between –49 and –50 for an overdepth of –50 feet) were not included in the paid overdepth of one foot.

(4) The swell factors used for excavation of the various materials to be encountered are 1.50 for basalt, 1.3 for Slaughters Bar, and 1.3 for the Vancouver Bar and turning basin areas, and 1.25 for the Broadway Bridge area.

(5) Top of rock was estimated from a combination of previous rock excavation contract as-designed data and from fathometer surveys as follows:

(a) Previous excavation removed all rock above at least elevation (El.) –45.5 in the Columbia River except where otherwise noted.

(b) Previous excavations removed all rock above El. –44.5 in the Willamette River except where otherwise noted.

(c) No rock occurs above the elevations indicated on hydrosurvey charts made from about 1982 through May 1997.

(6) Excavation quantities are estimated only for known or adjacent to known areas of previous rock removal except for the Slaughters Bar, Broadway Bridge, Lower Vancouver Bar and Turning Basin, and Morgan Bar areas.

(7) Excavation rock quantities include, where applicable, material present up to 10 feet outside the present channel boundaries.

(8) Quantity computations assume vertical cuts, although final rock cut slopes will be designed as 4V on 1H.

3. Geology.

a. Physiography. The lower Columbia River between Portland and its mouth crosses two distinct geologic provinces, the Puget-Willamette Lowlands and the Coast Range. The Columbia River flows north from Portland along the western border of the Puget-Willamette Lowlands and then turns westward near Longview, Washington, to traverse the Coast Range. The Willamette River flows northward within the Willamette Valley Section of the Puget-Willamette Lowlands and joins the Columbia River at Portland, Oregon. The Puget-Willamette Lowlands is a structural basin consisting mostly of alluvial plains and gently undulating hillsides with locally scattered, steeper rocky hillocks. The Coast Range trends north - south, averages about 1,500 feet in elevation, and includes numerous steep sided rapidly eroding valleys. The coastal plain is relatively narrow and at the Columbia River mouth consists mostly of an enlarged embayment. The Columbia River eroded a much deeper channel beneath the present riverbed during sea level fluctuations that occurred during the Pleistocene and Holocene (Recent) Epochs. Sea level has risen an estimated 100 feet or more during the past 15,000 years resulting in a drowned valley mouth.

b. Riverbed Materials. The ancient Columbia River Valley has been filled with widespread sand and gravel deposits from as far away as Montana and Idaho. The present riverbed consists mostly of sands and local fine silts. Rock only occurs where the river has shifted out of its previous channel over onto the previous side valley slopes. Most of this rock is expected to consist of local layers of dense, hard basalt or basalt flow breccia. Locally resistant igneous intrusives also remain at some locations. Sedimentary siltstones, sandstones, and conglomerates are less common, but also occur within the present streambed area. Materials encountered downstream from the Cowlitz River mouth in Slaughters Bar Reach and to a lesser extent in Walker Island Reach consist of cemented or compact dense gravels, cobbles, boulders, and rock blocks in a clay matrix. The Slaughters Bar materials have also been identified as rock. Whether rock or consolidated rock fragments, they can be expected to be difficult to excavate and are likely to require large excavation equipment. Fine silts from the Portland Harbor below present project maintenance depths have in the past had to be excavated during non-fish periods due to the turbidity caused by excavation.

c. Sedimentary Conditions. The lower Columbia River floodplain width varies considerably from about 1.5 to 9 miles, with numerous sand bars both natural and artificially created by deposition of dredged materials, forming islands along much of the river. Sediments tend to be deposited primarily during winter and late spring. Suspended load has been estimated to average 10^6 metric tons a year, and average bed load discharge has been estimated at the mouth as 10^5 metric tons a year. Upstream bed load must be considerably less than at the mouth since only minimum amounts of sediment have accumulated in Bonneville Lake. River bottom characteristics are continuously changing with areas of erosion and accretion occurring continuously in most areas.

4. Rock Areas and Quantities.

a. General. Locations of known and suspected rock bodies within and adjacent to the existing channel limits are discussed in the following paragraphs. Estimated rock quantities and approximate locations are presented on Table 1.

b. Wauna Bar. An area of basalt rock occurs at Wauna Bar near Columbia River Mile (CRM) 42. Rock was supposedly removed from five locations within the channel limits and from three locations adjacent to the channel in the mid-1960’s. Pre-construction records indicate the rock removal pay line was to be El. –46, but the required project depth and sweep line for rock removal was to be El. –45. It can be assumed that rock was removed to at least –45.5. This reach was contoured to a bottom elevation of –50. The cumulative compilation of fathometer surveys shows no material occurring above –47. This area is shown on Figure 1.

c. Stella-Fisher Bar. A basalt rock pinnacle located near CRM 56 in the Stella-Fisher Bar Reach was excavated to approximate El. –47 in the mid-1970’s. Exact depth of rock removal is not known and the specifications indicate that there was a 1- to 2-foot tolerance line for rock removal. The cumulative compilation of fathometer depths indicates the area is now greater than –47 feet. This reach was contoured to a bottom elevation of –50. This area is shown on Figure 2.

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d. Slaughters Bar.

(1) General. Materials of questionable composition, but sufficiently difficult to excavate that they should be considered as rock, occur at Slaughters Bar and the upper portion of Walker Island Bar, from approximate CRM 63 to CRM 67. Materials removed from this area in the mid-1960's consisted of plastic clay and coarse gravels. Additional materials were removed in the mid-1970's, but no data could be found on the nature of these materials. Design memorandums indicate the mid-1970's material removal pay line was to be at El. –45 and the required project depth and sweep line were to be at El. –44. It can be assumed that material was removed to at least –44.5. This reach was contoured to a bottom elevation of –48. This area is shown on Figure 3.

(2) Composition of Materials. Materials to be excavated from Slaughters Bar Reach are either well cemented gravels, cobbles, boulders and displaced large rock blocks, or in-place rock. Construction data for Longview Bridge which is in the Slaughters bar Reach indicate the bridge is underlain at depth by compact sandy gravel, cobbles, and boulders, and that the piers adjacent to the channel were founded in this material at elevations of –60.7 and –72.0. A 1970 drill hole near an Oregon shore pier indicated similar materials to El –129. Bedrock beneath the river channel at the Trojan Nuclear Site (approximate river mile 73) is estimated through geophysical explorations to be below El. –300. Material thought to be in-place rock was encountered, however, in 1970 clamshell explorations at elevations as high as –40 within the channel in the vicinity of the bridge. This rock was classified at different locations as hard gray basalt, green flow breccia, or slab rock.

(3) Explanation of Interpretations. A possible explanation for the different materials encountered could be the result of past Mount St. Helens volcanic eruptions. Volcanic debris including fines, sands, gravels, cobbles, boulders, and large rock blocks could have been disgorged from the Cowlitz River mouth and deposited beneath the existing Columbia River channel, and could even have resulted in the southward relocation of the Columbia River from its original deeper channel to a much shallower channel perhaps in part flowing over rock at its present location.

(4) Difficulty of Excavation. Excavation of material from Slaughters Bar Reach is expected to be difficult, no matter which interpretation of geologic conditions or material classification is used. Clamshell explorations with a 2.5 cubic yard bucket were unable to penetrate the materials classified as rock. It is anticipated that large mechanical excavation equipment will be able to remove all material except for any in-place rock or displaced large rock blocks encountered. Blasting will likely be required to remove any in-place rock and any displaced large rock blocks encountered.

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e. Warrior Rock. An area of basalt rock occurs at Warrior Rock near CRM 87. Rock was removed from this area in the mid-1960's. Pre-construction records indicate the rock removal pay line was at El. –44, and the required project depth and sweep line for rock removal was at El. –43. It is assumed that rock has been removed to at least El. –43.5. The cumulative compilation of fathometer depths indicates rock is present above El. –45. This reach was contoured to a bottom elevation of –50. This area is shown on Figure 4.

f. Morgan Bar. A suspected rock area occurs in the Morgan Bar Reach near CRM 101. Known rock on the west bank appears to project out into the channel between approximate Stations 100+38+00 and 100+50+00. Explorations need to be accomplished in this area to verify the presence of rock. If rock is present in this area, it will probably be basalt, requiring blasting methods for removal. The cumulative compilation of fathometer depths identify material present above El. –47 feet. This reach was contoured to a bottom elevation of –50. This area is shown on Figure 5.

g. Post Office Range – River Mile 7.5. An area of basalt rock occurs in Portland Harbor within the Post Office Range – River Mile 7.5 reach between approximate Willamette River Mile (WRM) 4 and WRM 6. Rock was removed from five locations within the channel limits and from two locations adjacent to the channel. Rock excavations occurred in both the mid-1960's and again in the mid-1970's. Design memorandums for the mid-1970's excavations indicate the rock removal pay line was at El. –45 and the required project depth and sweep line for rock removal were at El. –44. Based on this, it can be assumed that rock was removed to El. –44.5. Rock could possibly be higher in some of these locations, however, since not all of the locations of the mid-1960's excavations were re-excavated in the mid-1970's. The mid-1960's rock removal pay line was at El. –43 and the rock removal line was at El. –42. Thus, some rock could possible be found as high as approximate El. –42.5. A proposed channel realignment has been used to miss some of the known rock bodies to minimize the amount of excavation required. Rock quantities have been calculated only within the proposed channel limits. Even so, as excavation gets deeper in the vicinity of these known rock bodies, the chances of encountering additional rock increases. Results of cumulative compilation of fathometer depths has identified additional possible rock bodies or extensions of existing rock. Explorations will need to be conducted to verify the existence of rock. This reach has been contoured to a bottom elevation of –47. This area is shown on Figure 6.

h. Broadway Bridge Area. An area of known sand, gravel, and boulders is present just downstream of the Broadway Bridge, between WRM 10 and WRM 11. This area was identified through water jet probe explorations conducted during the 1960's. No information is available as to the final rock removal depth. It is anticipated that mechanical dredging equipment, such as a clamshell will be required to remove this material. Cumulative compilation of fathometer depths shows material present to around El. –43 on the northern margin of the proposed channel realignment. This portion of the reach has been contoured to a bottom elevation of –47. This area is also shown on Figure 6.

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i. <u>Lower Vancouver Bar and Turning Basin</u>. Vancouver Bar excavations in the past have encountered considerable amounts of "…cemented sand and gravel, hard-packed sand and gravel, and cobblestones." One area encountered during the last deepening occurred near CRM 105. This area required heavy-duty mechanical dredging equipment to break up and remove the rock material. The character of this material is not consistent, cemented areas are found in a variety of areas at different elevations, making quantity estimates difficult. Cumulative compilation of fathometer depths shows material is present up to El. –46. These reaches have been contoured to a bottom elevation of –48. This area is shown on Figure 7.

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5. Bridge Pier Analysis.

a. General. An analysis of the bridge piers within the channel deepening limits was made to determine the likelihood of compromising the bridge foundations by the removal of overburden or rock or through scour at the pier foundation. All available design drawings and foundation information for all bridges was secured and analyzed based on the new proposed channel depths and alignments. It was assumed that the maximum channel depth for the Columbia River was El. –48 with an El. –50 rock depth. A maximum study depth of El. –45 with an El. –46 rock depth is assumed for the Willamette River.

b. Astoria Bridge. The Astoria Bridge crosses the Columbia River at approximate River Mile 13.6. The existing channel in this location is, for the most part, deeper than the study depth, however, the channel approaches 40 feet at the southern limit. This would necessitate dredging up to 8 feet of overburden which is most likely sands and silts. There is no current information on the foundation material but design drawings indicate sand and silt to a depth of at least 80 feet. It does not appear that the maximum study depth will cause a problem with either main pier. Design drawings show the south pier to be founded slightly deeper (approximate El. -100 feet NGVD to the top of the piles) than the north pier (approximate El. -80 feet to the top of the piles) where the channel is substantially deeper than the maximum study depth. Additionally, design drawings indicate the channel was approximately -47 at the time of the contract for the bridge piers. Significant scour is not anticipated given the tidal fluctuations and the width of the river at this point.

c. Longview Bridge. The Longview Bridge crosses the Columbia River at approximate River Mile 66. There is no indication that the maximum study depth will have a detrimental effect on the bridge piers if the current channel configuration is maintained. The piers appear to be founded on gravelly sand at elevations of –60 and –72 for the main piers and –50 for the two secondary piers near each side of the shore. A current hydrosurvey of the area indicates the Longview port area limit is at least 100 feet upstream of the bridge alignment. If the port area is adjusted any nearer to the alignment of the bridge, pier #4 (closest to the north shore) will need to be examined more closely. Flows high enough to scour the gravelly sand are not anticipated in this area of the river due to the width of the channel.

d. St. Johns Bridge. The St. Johns Bridge crosses the Willamette River at approximate River Mile 5.8. It does not appear that the maximum study depth will cause a problem with either main pier. The most recent hydrosurvey indicates the channel is near or below the maximum study depth in the area of the bridge. The new Willamette channel alignment crosses beneath the bridge to the east side where the channel is the deepest. Oregon Department of Transportation drawings indicate the current channel limits are approximately 350 feet from the east main pier. Given the minimal amount of dredging in the area, the distance from the channel limit and the fact that the pier is rip-rapped to elevation –30 it is not likely the pier will be affected. The east main pier is founded on piles that have an average depth of –85 and are cut-off at –49; the foundation material is sand. The west main pier is founded into rock at least 2.0 feet at an approximate elevation of –25.

e. Burlington Northern Railroad Bridge. The Burlington Northern Railroad Bridge crosses the Willamette at approximate River Mile 6.9 Rock throughout the area is for the most part deeper than the proposed rock excavation depth of El. –46. The main west pier (no. IV), however, is founded at –45.9. A thin layer of rock extends up to about El. –43 adjacent to the pier and extends about 15 feet into the channel at El. –46. It is proposed to remove the overburden to this rock line and leave this portion of the rock intact adjacent to the pier. The main east pier is founded at a depth of approximately –80 and is not a concern. Preliminary information indicates the piers are founded on Troutdale Formation; this material is generally fairly hard cemented gravels, however, it tends to have pockets of fairly soft material.

f. Fremont Bridge. The Fremont Bridge crosses the Willamette River at approximate River Mile 11.1. The piers for this bridge are founded on land and will be unaffected by a deepening of the channel.

g. Broadway Bridge. The Broadway Bridge crosses the Willamette at approximate River Mile 11.7 and is at the upstream end of the 40-foot channel. Piers 5 and 6, in the middle of the river, are supported by timber caissons installed in the river bottom from El. –30 to –80. Materials adjacent to the caissons are anticipated to be unconsolidated sediments, based on the depth of the caissons. There is no information available on foundation material and current channel depth at the piers at this time. Underwater examinations of the piers and caissons reveal that the exposed timber framework is still intact. It is not likely a problem would be created with excavation.

6. Blasting Information.

a. General. Blasting will be required to remove in-place basalt from several areas within the Columbia and Willamette Rivers. Blasting has been accomplished in the past during previous rock removal contracts in the 1960's and 1970's. Unfortunately, very little information is available detailing how blasting was accomplished in these areas, leaving questions as to the character of the rock remaining.

b. Rock Requiring Blasting. Blasting will be required to remove rock to El. –50, which is the projected pay line, at Wauna Bar, Stella Fisher Bar , Warrior Rock, and possibly Morgan Bar on the Columbia River. Blasting will also be required to remove rock within the Willamette River at several possible locations in the Post Office Range to River Mile 7.5 Range to El. –47. Rock is all anticipated to be basalt, which is a hard, igneous rock created as a terrestrial lava flow. The character of this material is unknown, other than the hardness. Depending on location within the flow, the rock may be massive or highly jointed. Also, due to previous blasting techniques, the upper surface of areas of previous rock removal may be highly fractured, with loose material present at the surface of rock body. Explorations are required to determine the true nature of the material.

c. Proposed Blasting Plan. The proposed blasting plan is patterned after rock removal efforts conducted by New York District for channel improvements done to Kill Van Kull and

Newark Bay Channels. Rock encountered in these excavations is a diabase, which is similar to the basalt in the Columbia and Willamette Rivers. Drill holes measuring approximately 4.5 inches in diameter are to be placed on a 10-foot by 10-foot pattern drilled approximately 10 feet below the new grade line. Explosives to be used are expected to be a cartridged water gel. Rock would be removed after blasting by clamshell.

d. Mitigation of Blasting Effects on Fish. All possible measures are to be utilized to minimize blasting effects on fish during rock removal. Blasting will only be accomplished during scheduled in-water work periods. Actual blast effects will be minimized by limiting peak overpressure from blasting to 10 psi or less at the least distance possible from the shot area. This can be accomplished by ensuring every shot will have blasting delays such that explosives in each individual blast will be detonated on a different delay. This will limit the pounds of explosives per delay to about 100 pounds maximum. Information collected from other projects using this criteria indicate that peak overpressures can be controlled to 10 psi or less at distances of 30 to 50 meters from the blast point. Hazing tactics will be employed to scare fish from the immediate area just prior to each blast.

7. Explorations. Explorations are proposed for upcoming PED Phase work to better identify the location and extent of the rock bodies and to better determine the quantity and character of the material. Explorations are to begin with geophysical investigations utilizing sub-bottom profiling techniques to better determine the presence and depth of rock bodies. Once known and suspected rock bodies are better identified, a series of water jet probes and core drill holes will be placed at specific locations to verify the depth to, nature of, and quantity of rock. The nature of the rock, whether massive, jointed, slightly or highly fractured, will aid in what specific equipment or techniques will be necessary to remove the material. Planned explorations, including approximate numbers and costs are included in Attachment 1.

Geotech PED cost estimate

28-Oct-98

CHAPTER 7

COLUMBIA RIVER CHANNEL DEEPENING

DRAFT BASELINE COST ESTIMATE (BCE) NARRATIVE

COLUMBIA RIVER, OR/WA

1. Project Description: The Columbia River Channel Deepening (CRCD) project will consist of deepening the existing navigation channel from RM 6.0 to RM 105.5 on the Columbia River, and RM 0.0 to RM 12.0 on the Willamette River. The channel will generally be deepened from the current authorized depth of 40 feet to a new depth of 43 feet. The typical width of the navigation channel will be 600 feet, the same as the existing channel. About 25,700,000 CY of sand and 924,000 CY of rock or rock-like materials will be dredged. Hopper, pipeline and clamshell excavation methods will be employed. Hopper dredge disposal will be at designated ocean disposal sites, and flow lane sites. Disposal for pipeline and clamshell dredging will be primarily at existing and new upland disposal areas, with some flow lane disposal for rock excavated by clamshell. Five mitigation areas will be constructed. The baseline cost estimate (BCE) covers only new deepening work. No operations and maintenance dredging costs are included in the BCE.

Estimates have been prepared for two different plans, the sponsor's plan and the Corps of Engineers (least cost) plan. These plans differ primarily in disposal locations. The sponsor's plan proposes the use of several upland disposal areas that would be more expensive than those included in the Corps plan, because the sponsor's plan sites were a greater distance from the river reaches to be dredged. The sponsor has proposed these more distant sites because they can sustain industrial development if filled with dredge material, or the material can be sold for commercial uses. The estimate for the Corps plan is the least cost plan and is therefore the BCE. The Corps plan estimate (BCE) reflects the amount requested to be authorized by Congress, and will be the amount subject to the 902 limit. However, the sponsor's plan may be adopted for implementation, because the sponsor has agreed to pay the difference between the cost of the sponsor plan and Corps plan.

2. Basis of Design. The basis for the design of the deepening project is given in the Feasibility Report, to be published in Fall 1998.

3. Estimate References:

ER 1110-2-1302 (Civil Works Cost Engineering), APPENDIX G (Preparation of Dredge Cost Estimates)

EP 1110-1-8 (Construction Equipment Ownership and Operating Expense Schedule)

4. Construction Schedule: The proposed construction schedule is given below. Dredging is assumed to begin on June 1 each year. This schedule indicates that the proposed work can be accomplished within the 2-year construction time frame.

DREDGING REACH	VOLUME	DREDGING TYPE	PLANT
		YEAR 1	
U/S of CRM 78	700,000	O&M	Hopper
CRM 42-78	7,777,000	Construction	2 - 30" pipelines
CRM 29-78	2,783,000	Construction	Hopper
CRM 3-29	6,511,000	Construction	2 - Hopper
CRM 63-67	246,000	Construction (Rock)	Clamshell
Columbia/Willamette	255,000	Construction (Basalt)	Drill & Blast
		YEAR 2	
U/S of CRM 78	7,349,000	Construction	2 - 30" pipelines
D/S of CRM 78	3,000,000	O&M	30" pipeline
D/S of CRM 78	4,000,000	O&M	Hopper
Willamette River	1,200,000	Construction	Hopper
CRM 101-107	390,000	Construction	Clamshell
WRM 7-11	33,000	Construction	Clamshell

a. Overtime. Overtime will probably not be necessary except on the rock excavation. The hopper, pipeline and clamshell dredges will be operating 24 hours a day 7 days a week; however, there will be three shifts a day for each dredge. The rock excavation by drillboats will be operating 10 hours a day, 6 days a week.

b. Construction Windows. Fisheries agency concerns about fish entrapment and interference with salmon migration have resulted in designated in-water work periods in the Columbia and Willamette Rivers. The pipeline and hopper dredging windows are June to February (9 months). Clamshell dredging can occur year-round. The in-water work period for blasting in the Columbia River will run from November to February. In the Willamette River, the in-water work period for blasting will run from March to October. These blasting windows would allow drilling and blasting operations to be conducted intermittently until completed.

c. Acquisition Plan. It is anticipated that construction will require 2 years to complete. Three major dredging contracts were planned, one for removal of common materials (primarily sand) by hopper, another for removal of common material by pipeline, and one for rock excavation. Additional dredging contracts may be required if annual funding limitations occur. Upland disposal site improvements will be accomplished during the dredging contracts.

A separate contract will be used to construct the mitigation areas. Utility owners will be responsible for accomplishing the relocations of their underwater utilities.

5. Subcontracting Plan. No subcontracting is anticipated in any of the contracts.

6. General Estimating Information.

a. Determination of Types of Dredging. The types of dredging equipment assumed to be used, by river mile, were determined by Corps design personnel for the Corps plan, and by sponsor personnel for the sponsor plan. Factors considered included economics (D2M2 program), river conditions, distance to disposal areas, past practice, and judgement.

b. Estimating by River Mile. The cost of the dredging was estimated river mile to adjacent river mile, in order to accurately capture costs of varying quantities, depths of cut, distances to disposal site, and types of dredging equipment.

c. Sources of Dredging Information. Sources of dredging expertise consulted in the preparation of the BCE include: John Chew of New York District, Kim Callan of Walla Walla District, Bob Parry of Seattle District, Manson, Great Lakes, Dutra, Corps personnel from SF District and LA District, and Ogden Beeman & Associates, Inc., representatives of the sponsor. There have been no large dredging contracts on the Columbia River in recent years except for hopper dredging. However, the historical dredging information used was modified to account for the conditions anticipated on the Columbia River including river flows, traffic, current and congestion in the work area.

d. Sources of Historical Data. Previous projects used as sources of historical data include: Coos Bay Channel Deepening, Oakland Harbor Channel Deepening, Los Angeles Harbor Deepening, and the Kill Van Kull Channel Deepening in New York Harbor. Historical information obtained for these projects included types of equipment used, labor crew makeups, production rates and difficulties encountered that might be similar to those anticipated for CRCD. Additional information was obtained from modifications to these projects, which included audited monthly equipment costs. Unit costs developed in the BCE were compared to actual costs from these projects to assess reasonableness of the estimate.

e. Hazardous, Toxic and Radioactive Waste (HTRW) Remediation Costs. No specific costs for HTRW remediation were included in the BCE. A waiver was received from Higher authority which stated that HTRW aspects did not need to be considered in the Feasibility phase, but that they must be considered in the Planning, Engineering and Design (PED) phase of the project. Costs for the HTRW explorations and analysis work, to be accomplished during PED, are included in the BCE. HTRW remediation work is expected to be minor in nature, primarily at the upland disposal sites. Therefore associated remediation costs will be relatively small. These costs are considered to be covered by contingencies in the BCE.

f. Site Access. Access to the dredging areas should not be difficult, since these areas have been dredged in the past. Access to some of the disposal areas and mitigation areas must be developed, but will generally not be difficult.

g. Rock Borrow Areas. Outfall rock at the disposal areas will be acquired from commercial quarries. Several quarries up and down the river will be used. A representative quote for the rock materials was obtained from Goble Quarry.

h. Production Rates for New Work Dredging. The new work dredging of sand materials will likely be slightly slower than is the usual maintenance dredging. The new work materials are probably a bit denser than the O&M materials, since the channel has not (theoretically) ever been dredged from 40 feet to 43 feet.

i. Equipment/Labor Availability. Hopper, pipeline and clamshell dredge(s) of the appropriate sizes will most likely be available on the west coast at Seattle, San Francisco or Los Angeles. Drill boats are expected to be mobilized from the east coast (Florida) or assembled from scratch at a facility on the west coast. Appropriate crew members will likely come with the dredge plant.

j. Environmental Concerns. See EIS and Feasibility Report.

k. Contingencies by Feature or Sub-Feature.

1) Construction Contingency. A contingency of 15% has been used for the 09 account (hopper, pipeline and rock excavation) to cover uncertainties in all the dredging quantities, and in the unit prices for rock excavation and pipeline dredging in particular. The unit prices for hopper and clamshell dredging are more certain. The range of acceptable crew composition, operating costs, production rates, equipment availability, uncertain weather conditions, ship traffic and material variations are also covered by the construction contingency. A contingency of 25% has been used for the 09 (mitigation) to account for uncertainties in quantities and unit prices.

2) Contingencies for Functional Accounts. The contingency included in the 01 account cost are 5% for the disposal sites and 9% for the mitigation sites. Contingencies of 10% were included in the 30 and 31 accounts to cover uncertainties in engineering, design and construction management related 09 accounts discussed above.

l. Effective Dates for Labor, Equipment, Material Pricing. The effective date for all pricing is May 1998.

7 . Quantities.

a. Typical Cross-Section. A cross-section sketch is provided for the typical excavation prism which shows the pre-dredge survey data, the required dredging pay depth, the maximum dredging pay depth, and the post-dredge survey data. The dredging area design width and slopes are also shown. See attachment 1.

b. Computation of Common Dredging Quantities. The quantities of common excavation were computed based on channel sounding data obtained in the Winter/Spring of 1995, and on the maximum dredging pay depth. Standard dredge quantity software was used to generate the quantities. The quantities of rock excavation were deducted from the appropriate river reaches.

c. Computation of Rock Excavation Quantities. The quantities of rock excavation were computed based on historical locations of rock in the Columbia and Willamette Rivers, and the summation of condition surveys conducted over recent years. The lowest levels to which these sections of river have been dredged were considered top of rock. Then quantities of rock to be removed were computed based on the top of rock and proposed excavation depths.

Quantities of the conglomerate rock to be excavated at Slaughter's Bar, Lower Vancouver Bar and Vancouver Turning Basin, all of which are on the Columbia River, were based on a depth of 47 feet, plus one foot paid overdepth. For the Broadway Bridge reach quantities for conglomerate rock were computed to 46 feet plus one. For basalt to be blasted and removed in the Columbia River, quantities were computed to a depth of 49 feet plus one. In the Willamette River, basalt quantities were computed to 46 feet plus one.

Only volumes inside the contour for the required excavation depth were included in the rock quantities. Quantities outside the excavation contour (46, 47, and 49 feet depending on location) were not included in the paid overdepth of one foot.

Rock will be excavated several feet below the proposed new authorized depth of 43 feet in order to minimize damage to dredges during future O&M dredging operations.

d. Combination of O&M and New Work Quantities. Both new work and O&M quantities will be dredged under these contracts, but only the new work costs were included in the BCE. Combining these materials will lead to greater efficiency than would be accomplished by dredging the O&M materials and then the new work materials. Dredging unit costs were estimated in CEDEP using the combined new work and O&M quantities, then the new work quantities were input into MCACES, along with the unit prices generated in CEDEP.

e. Overdepth Quantities for Dredging of Sand. Paid overdepth quantities (one foot below the required excavation line) were included in the required excavation quantity. For purposes of this estimate, all of this overdepth is assumed to be dredged, since a contractor might choose to maximize his pay amount by dredging all paid yardage. A 0.5-foot overdig amount, below the maximum dredging pay depth, was added as non-pay yardage for pipeline and clamshell estimates. For hopper dredging, non-pay yardage was determined based on historical data from sand wave dredging accomplished by the dredge Newport in recent years. See paragraph above for planned overdepth in rock.

f. Quantities Along Channel Slopes (in Sand). These slopes often slough during dredging, making it difficult to clean out the corner between the channel bottom and the slope. This added dredging effort is accounted for by the paid overdepth, the unpaid overdepth, the added cleanup dredging time, and contingencies. For the pipeline a 5% cleanup dredging time was added and for the clamshell a 15% was added.

8. Corps of Engineers Dredge Estimating Program (CEDEP).

a. General. CEDEP was used to prepare the dredging estimates for all hopper, pipeline and clamshell dredging, including mobilization and demobilization of the dredges and associated equipment. The rock drilling and blasting, upland disposal site development, mitigation area and utility relocation estimates were prepared using MCACES. All overhead, profit and bond were computed in MCACES, not in CEDEP. An Excel version of CEDEP that was converted from Lotus was used for clamshell rock excavation estimate. The new Excel version of CEDEP was used for the hopper and pipeline dredging estimates.

b. Dredging Areas. Areas to be dredged were provided by Cartography, by river mile. The areas to be dredged were used in CEDEP with the excavation quantities to determine the depth of cut, which has a very important effect on dredging costs.

9. Inputs to CEDEP.

a. Density of Sand. All non-rock was assumed to be loosely deposited sand weighing about 1,900 grams per liter. A material factor of 1.0 was used for this loose sand material.

b. Crew Makeups. Crew makeups were modified in CEDEP, where necessary, using recent experience on large pipeline, clamshell and hopper dredging projects.

c. Equipment Rates. CEDEP equipment rates were used in some cases, while audited equipment rates from modifications on recent dredging contracts were used in other cases.

d. Labor Rates. Labor rates were updated using recent Davis-Bacon information. A workman's compensation rate of 30% was used in CEDEP and MCACES dredging labor. This reflects longshoreman's insurance rates per review of modification estimates and discussions with SAIF personnel. Overtime percentages were computed in CEDEP and MCACES as appropriate.

e. Hydrosurveys. Hydrosurvey costs were included in CEDEP, including a survey boat and crew. Costs for pre-dredge surveys, surveys during construction and post-dredge surveys were covered.

f. Permits. No permits need to be obtained because all environmental clearances will be covered by the EIS. Thus no costs associated with permits will be incurred.

g. Fuel Price. A fuel price of $0.70 per gallon for diesel fuel was used in the CEDEP program. This is the price for diesel fuel in the Portland area when provided in bulk to a marine customer.

h. Interest Rate, Economic Index. A cost-of-money rate of 6.25% per year was used. This was the rate in June 1998. An economic index of 6145, which reflects 2000 costs, was used.

i. Cleanup Factor. A cleanup factor of 0.95 was used for the pipeline and hopper dredging. For rock excavation a cleanup factor of 0.85 was used. This factor covers an estimated 5% and 15% additional dredging time required after the major dredging work is complete, to cleanup slopes and corners where surveys show material was missed, or where sloughing has occurred, respectively.

j. Bank Factor. The quantity for a given reach of river in combination with area to be dredged yields a bank height, which is converted to a bank factor in CEDEP. This factor varies for the different dredge types. The greater the bank factor, the more efficient the dredging operation is, up to a maximum point where no further improvement in efficiency results.

k. Effective Working Time (EWT). Dredges will typically work 7 days a week, 24 hours a day, due to the high capital expense associated with the purchase of these machines. However, maintenance activities will reduce the actual working time somewhat, based on the type of dredge, types of material being excavated, and the condition of the equipment. An EWT percentage of 80% was used for hopper and 65% for pipeline dredging based on historical performance. For basalt rock excavation the EWT was set at 50%, due to high maintenance requirements resulting for the hardness of the rock material. The nonuniform nature of the rock material also affects the EWT. The EWT for excavating the conglomerate material using a clamshell dredge is about 52%.

10. Mobilization (Mob), Demobilization (Demob) and Preparatory Work. This will vary for the different contracts, depending on how the work is broken out. CEDEP has been used to compute mob and demob for each contract.

a. Initial Mob and Demob.

1) Sand Dredging Contract. This will consist of transporting two 30” pipeline dredges, one D-6 dozer and all associated equipment, and one medium sized hopper dredge. It is anticipated that this equipment will be available from various locations on the West Coast.

2) Rock Excavation Contract. This will consist of transporting 2 drill boats, one 21 CY clamshell dredge, two 2,000 CY scows, two 1,500 HP tugs and associated equipment.

a) Mobilization and Demobilization - Drill Boats. This has been calculated in detail for the drill boats in the backup. It is anticipated that 2 drill boats will be mobilized. Mobilization was assumed to occur from Florida. Demobilization would be back to Florida. The drill boats might be assembled from scratch at some facility on the West Coast. The cost of assembling drill boats on the West Coast would be roughly the same as mobilizing-demobilizing existing drill boats from the east coast.

A full crew, and 100% ownership and operational costs, were assumed for preparation and set-up of the drill boats. For transfer of the equipment, 25% of crew and operational costs were used, along with tug costs.

A tank barge with 60,000 lb capacity would be mobed to supply pourvex. Pourvex is the liquid explosive that would be used to blast basalt.

Initial mobilization was assumed to be to the Wauna/Driscoll reach on the Columbia River. Interim mobilizations were assumed to the remaining rock excavation sites. Demobilization was assumed from PO Range reach on the Willamette River.

b) Mobilization and Demobilization - Off-Loading Equipment. Off-loading equipment mob/demob has also been computed in the backup. Equipment included in this activity is: 966 loader, 35-ton crane, and 16 CY rock skiff, three dump trucks and D6 cat. Equipment requirements would vary between water based off-loading and land based off-loading. Initial and interim mobs between sites were computed.

b. Interim Mobs and Demobs. These were the mobs/demobs from one reach of the river to another. There were eight interim mob/demobs anticipated for the clamshell dredge (for rock excavation) and one for the hopper dredge. See the MCACES estimate for a listing of these mob/demobs, along with mileages from one reach to the next.

11. Hopper Dredging. Hopper dredging was estimated by the West Coast Team. Hopper dredging is assumed for use in the lower 30 miles of the Columbia River, where rough ocean conditions predominate, and at several other locations along the Columbia and Willamette Rivers where it is the more cost effective method. Disposal for hopper dredging will be accomplished at one offshore site and at eleven flowlane sites in the Columbia and Willamette Rivers. See the drawings for locations of disposal areas. Two medium-sized hopper dredges were assumed. The Padre Island, owned by Natco, was used as the reference dredge. It has a capacity of 3,800 CY. Cycle times and production rates were computed based on recent projects on which the Padre Island was utilized. A 5% increase in dredging time was assumed for new work yardage since it will be slightly more dense than the O&M yardage. Hopper dredging will be performed primarily in sand waves on the channel bottom.

12. Pipeline Dredging.

a. Determination of Pipeline Dredge Sizes. Pipeline dredge sizes were chosen as follows:

1) Various pipeline diameters (18”, 24” and 30”) were checked to obtain the least cost by river mile, but in the final analysis two 30-inch dredges were chosen to accomplish the work.

2) River miles were grouped together by disposal area.

3) Assured the dredging times were consistent with the project schedule, which calls for initial construction to be completed in 2 years.

It was decided to assume that all the new work pipeline dredging would be accomplished by two 30-inch pipeline dredges, working over two years. The first year, these two dredges would remove 7.7 mcy from downstream of RM 78. The second year, the two 30-inch dredges would remove 7.4 mcy from upstream from RM 78. In the second year, additional O&M dredging of the newly constructed channel downstream of RM 78 could add about 3 mcy of pipeline dredging and require a third 30-inch dredge.

b. Determination of Pipeline Lengths. Pipeline lengths were determined using maps generated by Cartography. Distances were scaled off from the centroid of a given RM to the centroid of the designated disposal area for that RM. Floating pipeline was assumed at a maximum of 2,500 LF, since it is the most expensive type of pipe, and this is the maximum amount of this type of pipe that is normally mobilized on a job. All other pipe used to traverse water was assumed to be submerged. Shore pipeline lengths were scaled off the maps. Average pipeline lengths were computed based on half the RM to be dredged, half the disposal area length, and the additional distance between the RM to be dredged and disposal area at their closest approach. A length of "Equivalent Additional Pipeline" was added to all pipeline estimates, in the amount of 1,000 feet. This covers any vertical height of pumping that might be required, as well as any abnormal pipeline losses.

c. Production Rates. Production rates for pipeline dredging were computed in CEDEP based on material type, bank height, pipeline lengths (distance to disposal areas), pumping horsepower, type of cutterhead, operator experience, effective working time, and cleanup time required. Standard production charts account for the above-listed data, and were used in CEDEP to compute production rates. Computed production rates are then compared to historical rates, as practicable, to assure reasonableness and are modified where appropriate.

d. Boosters. Use of boosters is sometimes necessary where pumping distances are high. The use of a booster leads to about a 15% loss in pumping efficiency per booster for the dredge, and can also be a disadvantage due to the maintenance problems they require. Occasionally their use is cost-effective; however, for long pumping distances or higher heads. CEDEP runs were performed with and without boosters to determine if booster use would yield lower unit costs. Boosters were determined to be cost effective at several river miles on the sponsor's plan.

e. Labor Crews. A pipeline dredging crew comprised of 21 personnel, 22 when a booster was required, was used in CEDEP. This covers all personnel required to work the dredge for three 8-hour shifts per day.

f. Pump Horsepower. Prime and secondary horsepower associated with the pumps on a 30-inch dredge were 9,000 and 3,310 respectively. Dredge pump horsepower relates to production rates and fuel usage.

g. Modified Dredge Areas. At a few RMs, computed bank height was too low for CEDEP to accomplish an estimate using a 30-inch dredge. At these RMs, the bank height was increased slightly to obtain output from CEDEP.

h. Variable Parameters in CEDEP. Key parameters that changed from RM to RM were: quantities, areas to be dredged, and pipeline lengths. All other parameters in the pipeline CEDEP runs remained constant from RM to RM.

13. Rock Excavation.

a. General. More details on the development of the rock excavation estimate are available in the backup material. Additional rock requiring excavation, beyond that included in the BCE, may be discovered during the PED phase of the project.

b. Mechanical Dredging. Removal of conglomerate rock in the Columbia River at RMs 63-67 and 105 will be accomplished using a clamshell dredge.

c. Blasting. Basalt in the Columbia River at RMs 42, 56, 87, and possibly 101, and in the Willamette River at RMs 3-7 and 10-11, will be broken up using blasting, with removal by a clamshell.

d. Dredge Type and Size. Discussions with industry personnel indicate that a 13 CY (rock) clamshell bucket would be appropriate for digging shot basalt in the Columbia River.

e. EWT for Clamshell Dredge. Based on historical record for previous rock excavation projects, an EWT of 50% was adopted for the blasted basalt to be removed at several locations. An EWT of 52% was adopted for dredging of the conglomerate materials at several other locations. The previous projects examined included: Coos Bay Channel Deepening; John Day Drawdown: Cargill Grain Loading Facility, Rock Dredging - 1/28 to 3/6/97; and SD & Lumber Rock Dredging - 2/25 to 3/2/95; and Kill Van Kull in New York.

f. Swell Factors. The swell factors used for rock are:

1) Basalt: 1.50

2) Slaughters Bar, Vancouver Turning Basin and Lower Vancouver Turning Basin Conglomerate: 1.30

3) Broadway Bridge boulders, gravels & sands: 1.25

Swell of the blasted basalt was computed based on the sum of the drill plus sub-drill depths. Sub-drilling (and hence the blasting) would occur to depths deeper than the design excavation depths. Thus, swelling would occur in both the rock above the design excavation depth, but also to a depth of rock (the sub-drill depth) below the design excavation depth. This additional swelling, and requisite additional excavation, is computed in the backup and accounted for in the basalt excavation estimate.

g. Disposal of Rock Materials. Disposal of rock materials will be accomplished at the following areas:

1) Slaughter's Bar material will go to O-65.7.

2) Materials from areas above and including Warrior Rock will go to Sauvy's Island (O-98.5).

3) Materials from Wauna/Driscoll will go to flowlane areas 3930 and 4000.

4) Materials from Stella/Fischer will go to flowlane area 5500.

Materials will be hauled on flat deck steel barges towed by 1500 hp tugs. Materials will be off-loaded at the disposal sites. A Cat 966 front end loader situated on the barge, and a 35-ton crane with a 16 CY skiff based on land were assumed for off-loading the rock. Rock will be unloaded from the skiff into dump trucks, which will haul materials to the actual disposal site. A D-6 dozer will spread the materials at the disposal site. The number of barges needed to allow for continuous excavation varies from site to site, as computed in the backup. CEDEP was used to assist in the computations. Fill factors, cycle times, production rates, and hauling times for each disposal site were computed in the backup and entered into CEDEP.

h. Blasting. Blasting will be used to loosen basalt materials. Drilling will be accomplished using drill boats similar to those owned by Great Lakes Dredge and Dock, or equivalent. These rigs were used recently on a project (Kill Van Kull) in New York that involved in-water blasting. The drill boats were about 150’ by 120’ in plan area, and each has 3 drills on board. A crew of about 16 people would man each drill boat. Drilling and shooting would only occur during daylight hours, because of safety concerns expressed by the Coast Guard and OSHA.. Velocities in the Columbia were similar to those experienced on the New York project, so they should be tolerable. Drilling will be accomplished on a 10’ x 10’ pattern, using 4.5-inch diameter holes which are 8’ to 10’ in depth. Steve O’Hara of Great Lakes has indicated that the daily direct cost of one drill boat, including equipment and labor, is $17,200/day in 1997 price level.

1) Blasting Materials and Supplies. The backup has calculations of the quantities and costs of the explosives, datacord, blasting caps, starters, and boosters anticipated to be used at the various rock excavation sites.

2) Drilling Production. Based on production levels achieved at New York Harbor, it is anticipated that 35 holes will be drilled per day by each drill boat. These holes will be drilled during one 10-hour shift per day. Drilling must be accomplished during daylight hours in the winter, therefore no more than a 10-hour shift will be used.

14. Upland Disposal Areas.

a. General. Designs for the upland disposal areas were received from the Sponsor. Designs for the disposal areas include several elements, such as dikes, spillway weirs, outfall pipes, pumping systems, utility relocations, clearing and grubbing, and access work. The containment dikes will be constructed of previously dredged sands. Ditches will be provided within the disposal areas as required to facilitate adequate drainage. Clearing and grubbing will be light.

b. Containment Dikes. Assume dike building crew would work 8 hours per day, 5 days per week. A D-8 dozer will be used for constructing dikes. The dike crew production rate is 360 LCY/hr.

c. Weirs. Weirs (spillways) have been assumed to be procured from Oregon Culvert of Tualatin, OR, (503)692-0410. Weirs will cost $6,500 each, FOB jobsite, including a riser and 2' stub for each weir. Discharge pipe will cost $47.00 per linear foot, FOB jobsite for 48-inch diameter 12 gage pipe. Bands, gaskets and bolts for the discharge pipe will cost $4.50 per linear foot, FOB jobsite. About 6 hours will be required to install each weir. Rock (12-inch minus) will be placed at the end of the outfall pipes to dissipate energy from drainage water. The cost of the rock will be $15/ton, FOB jobsite, as quoted by Goble Quarry, (503)556-9049. This is considered a typical outfall rock price for various locations along the river.

d. Return Water Pumpout Systems. Pumpout systems will be required at up to 4 disposal sites, and will generally be comprised of 40,000 gpm pumps at 20 feet of total head, with discharge lines. Pumping costs cover rental and operation/maintenance.

15. Mitigation Areas. Five mitigation areas are proposed. These measures are intended to improve wildlife habitat in several areas, as mitigation for construction of the upland disposal areas. Measures proposed include excavation of wetlands, dike construction, dike breaching, blockage of ditches, site tillage, irrigation, placement of snags and root wads, planting of riparian vegetation, clearing of blackberry thickets, removal of fencing, construction of water control structures, pumping, and construction of carp excluders.

16. Ecosystem Restoration. This consists of establishing wetlands in the Shillipoo Lake area, replacing 11 tide gates on the lower Columbia river at select locations, installing pile dike fields between Millar Sands and Pillar Rock Islands and excavating channels through spits at the upper end of Walker-Lord and Hump-Fisher Islands.

Developing the wetlands consists of constructing dikes and channels for areas or cells and installation of water control structures to regulate flow between the individuals cells. The new aluminum tide gates vary in diameter from 24 to 72 inches and have a manually operated fish slide gate attached for juvenile fish passage as needed. One or more new tide gates are to be installed at Deep River (RM 20), Grizzly Slough (RM 28), Warren Creek (RM 28), Tide Creek (RM 77), and Burris Creek (RM 81). The pile dike field between Millar Sands and Pillar Rock Island on the south side of the navigation channel consists of six pile dikes approximately 1,500 feet apart and each pile dike is 500 feet long. Construction of the channels at the upper end of Walker-Lord and Hump-Fisher Islands will allow Columbia River flow into the embayments adjacent to the islands thus improving circulation and lowering water temperature.

17. Utilities Relocations. Utility owners will be responsible for relocation of utilities affected by dredging and disposal operations. The costs of utility relocations are considered in the economic analysis, but are not included in the baseline cost estimate because the utility owners must bear these costs, not the Federal Government or Sponsor.

18. Use of MCACES.

a. General. CEDEP results (quantities and unit prices for hopper, pipeline and clamshell dredging) were entered into MCACES in a summary manner. Portions of the BCE were directly estimated in MCACES, including rock excavation, upland disposal site construction, mitigation areas, utilities relocations, field office overhead, home office overhead, profit and bond. No land-based positioning equipment was included in the MCACES, because a ship-based global positioning system will be used for this purpose.

b. Overhead, Profit and Bond. Field office overhead (FOOH) costs include: insurance costs, project superintendent (and/or manager), project engineer, clerical staff, project trailer, sanitary, project sign, telephone, pickups, quality control, environmental protection, and other miscellaneous items. Home office overhead (HOOH) was input as a “rule of thumb” percentage for this type and size of project. A HOOH percentage of 4% was used since all contracts will likely be over $500,000 in value. Profit was computed using the weighted guidelines sheet in MCACES. This project is not considered very risky, so the profit percentage is relatively low. Bond costs were computed using the built-in table in MCACES.

19. Functional Costs: Functional costs associated with this work were provided by the Task and/or Project Managers as follows:

a. 01 Account - Lands and Damages:

1) Right-of-Way Acreage: This is the land required for access to the disposal sites.

2) Disposal Site Acreage: This is the land required for the disposal sites.

b. 30 Account - Planning, Engineering and Design:

1) Plans and Specifications: This item covers preparing plans and specifications, District review, technical review, contract advertisement and award activities.

2) Engineering During Construction: This item consists of Planning and Engineering Division support to Construction Division during construction and participation in the prefinal and final inspections of the contracts.

d. 31 Account - Construction Management: This account covers construction management for the deepening contracts.